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MODELLING OF RUNOFF FOR EROSION STUDIES

by

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ACKNOWLEDGMENTS

This project is part of a broad effort to find erosion control methods suitable for the Pacific Northwest and the Palouse Prairie in particular. As in any broad based project, many people and organizations contributed to the work reported in this completion report.

The Idaho Water Resources Research Institute, through its allotment program, partially funded a graduate student and a technician as well as some computer time. The Palouse Conservation Field Station, Agricultural Research Service, USDA, Pullman, Washington also provided funding for the graduate student. Dr. D.K. McCool of that station was most helpful in locating study sites, locating and supplying data from the studies of the 1930's and, in general, being of the utmost help.

The overall coordination of the hydrologic modelling effort as it relates to erosion is in the Agricultural Engineering Department under an Idaho Agricultural Experiment Station Project entitled Erosion Research for Northern Idaho.

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INTRODUCTION

During the past few years, environmental awareness has heightened people's consciousness to the soil erosion problem. What once was only a concern of farm related groups has become the concern of everyone interested in preserving streams, recreation areas and aquatic habitat. In addition, the recent fluctuation in the price of farm products, the importance of exports to our national economy and the necessity of food exports to feed people of many nations has brought about a renewed interest in restoring and protecting the productivity of our farms.

The Palouse Hills area of Washington and Idaho is one of the leading wheat producing areas of the nation with wheat yields of 80 bushels per acre being common. Erosion was considered to be such a serious problem that an erosion research station was established at Pullman, Washington in 1931 (Horner and others, 1944). This station pioneered erosion control work in the Palouse. Experiments were conducted with various cropping systems and other methods of controlling erosion. It has never proved possible to incorporate the results of this work into the nationwide effort to predict erosion because of the vast difference in the precipitation regime of the Palouse and the area east of the Rocky Mountains (McCool and Johnson, 1973). Only recently has it been possible to incorporate some of these findings into an interim soil erosion equation based on the Universal Soil Loss Equation (McCool and others, 1976). This is recognized as a temporary equation until a more physically based equation can be developed.

The reason for the failure of erosion equations based upon the raindrop impact energy concept is that rains are gentle in the Palouse (100 year, 6 hour event is 1.8 inches) and most erosion results from water running on the soil surface and carrying soil with it. Most of this water results from snowmelt.

Studies of runoff in the Palouse area also started in the 1930's (Potter and Love, 1942). These studies were suspended during World War II but did result in good runoff data in the Palouse. Unfortunately, little documentation on frozen ground storm events can be found, but good information on erosion from running water is available from this study. Davis (1971) and Druffel (1974) published results from a small watershed study just east of Moscow, Idaho. These reports show very clearly the effect of surface runoff on erosion.

In order to develop a physically based method for erosion prediction, it is necessary to have a good method for determining the amount of surface runoff. Present day hydrologic methods are oriented towards modelling the entire hydrologic cycle which generally gives better results than modelling only the portion of interest. It also tends to pinpoint areas of the greatest lack of knowledge.

Experience with the Kentucky Watershed Model in the Palouse (Lee, 1973) and in Iowa (David, 1972).showed that this model was not suitable for an erosion model. A cooperative agreement with the Palouse Conservation Field Station, U.S. Department of Agriculture, Agricultural Research Service (ARS) at Pullman, Washington was initiated in July 1974 to assess various watershed models and their usefulness in modelling Palouse hydrology. The search soon centered on USDAHL-74, a model of watershed hydrology developed and refined by the ARS Hydrograph Laboratory through three versions (Holtan and others, 1975). This same model is also being evaluated by the ARS as the base hydrologic model for a chemical transport model called ACTMO (Frere and others, 1975). Based on this experience and the ARS commitment to this modelling effort, it was decided to look at USDAHL-74 in much more detail with a view toward adapting it for use in the Palouse, both as a hydrology model and a basis for an erosion model.

OBJECTIVES

The overall objective of this project was to further the understanding of the hydrology of the Palouse. The specific objectives set forth for this part of the broader effort are:

1. Evaluate the overall applicability of the USDAHL-74 watershed model to Palouse conditions.

2. Evaluate the overland flow routing of this model.

3. Evaluate the channel routing portion of this model.

4. Determine the range of watershed size that can be represented by the model.

5. Devise a means of extracting the necessary parameters and data from the model for a soil erosion and transport model.

PROCEDURES

Data Collection

The USDAHL-74 watershed model was obtained and verified as working correctly on the University of Idaho's IBM 370/145 computer using test data (Coshocton watershed, Ohio) supplied by the ARS. Thereafter, the program was modified or revised as necessary to operate under typical Palouse hydrologic conditions. The revisions are described in the next chapter.

The revised program was tested with data assembled from several locations in the Palouse area (Figure 1). The first location was the 8.2 acre Thompson watershed near Moscow, Idaho with two years of data (1971 and 1972 water years). These data include frozen ground runoff events as well as erosion, soil moisture, storm runoff and associated meteorological data (Davis, 1971; Druffel, 1973). These data would be useful for any future studies of erosion, frozen ground and soil moisture with the USDAHL model.

During the late 1930's and early 1940's, the Soil Conservation Service (SCS) operated several experimental watersheds in the Palouse as part of the South Fork Palouse River Demonstration Project and collected a large amount of cropping, soil, storm runoff, meteorological and erosion data. These data were published in 1941 (Soil Conservation Service, 1941; Potter and Love, 1942). The W-1 Pitzen farm watershed, a 146.8 acre area northeast of Moscow, Idaho was selected for this present study. Three water years, 1938, 1939 and 1940 were selected. These three years covered a wide range of climatological extremes.

These two watersheds are comparatively small agricultural watersheds. To test the USDAHL model on a large agricultural watershed, Missouri Flat Creek, 27.5 square miles (17,600 acres) was used. The creek is tributary to the South Fork Palouse River at Pullman, Washington. Three water years (1961, 1962 and 1963) were selected to test the model on this basin. Meteorological and runoff data at Pullman are available from USGS Water Supply Papers and National Weather Service publications.

The model was tested with three different size watersheds, Thompson (8.2 acres), Pitzen (146.8 acres) and Missouri Flat Creek (17,600 acres) (Figure 1). Two or three sequential water years' data were selected from each watershed. These watersheds represented a small, a medium and a large size watershed in terms of agricultural watersheds. Figures 2, 3, and 4 show the watershed contour maps. Three experimental plots (6' x 50', 6' x 100' and 6' x 150') near Pullman, Washington were also to have been used; but data collection and reduction is not yet complete since this report is being written at the end of the runoff season.

These three watersheds have similar hydrologic and physiographic conditions except for size and shape. Table 1 shows some of the characteristics of these watersheds.

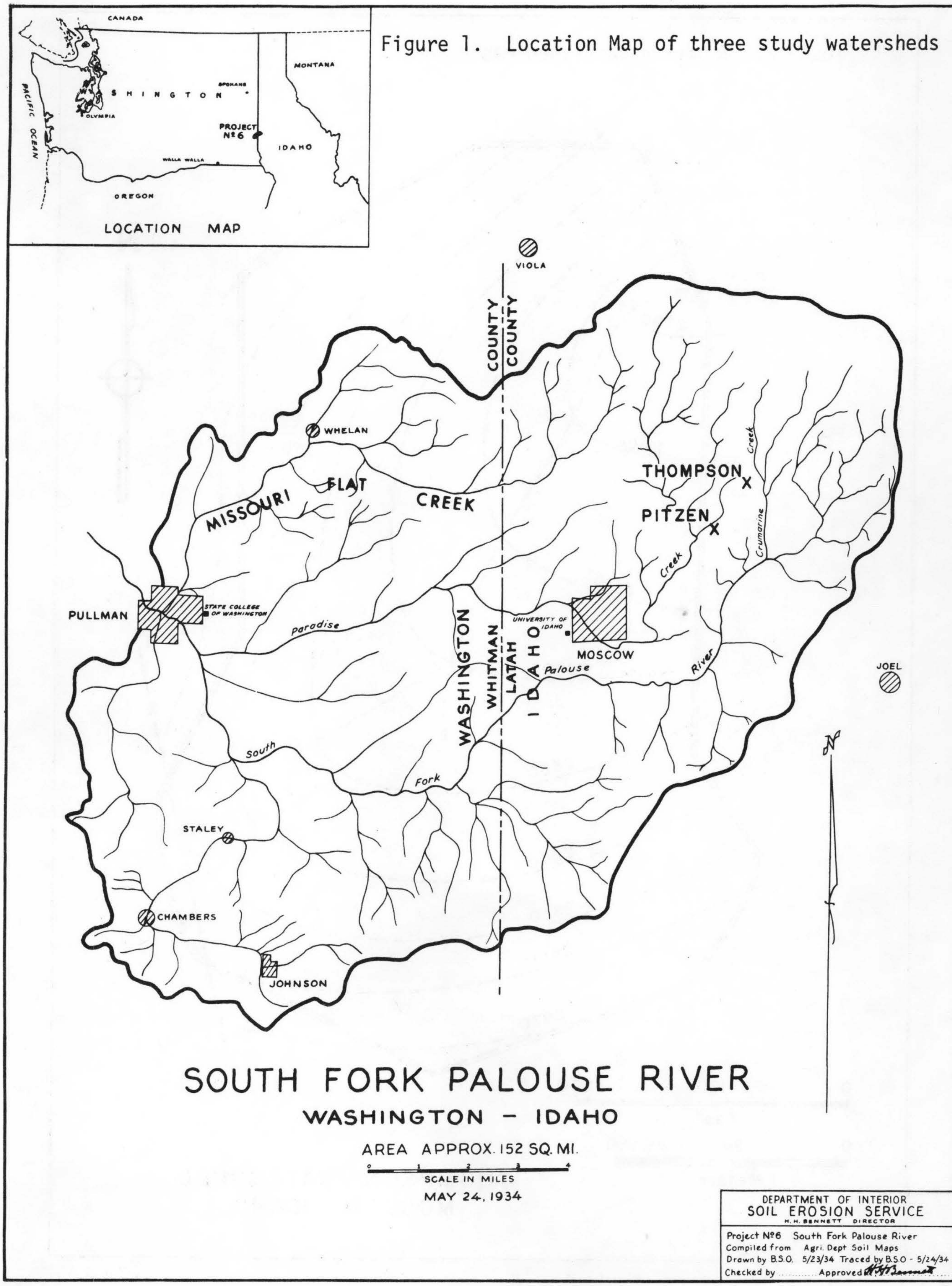

Figure 1. Location Map of three study watersheds

Figure 2. Thompson watershed map

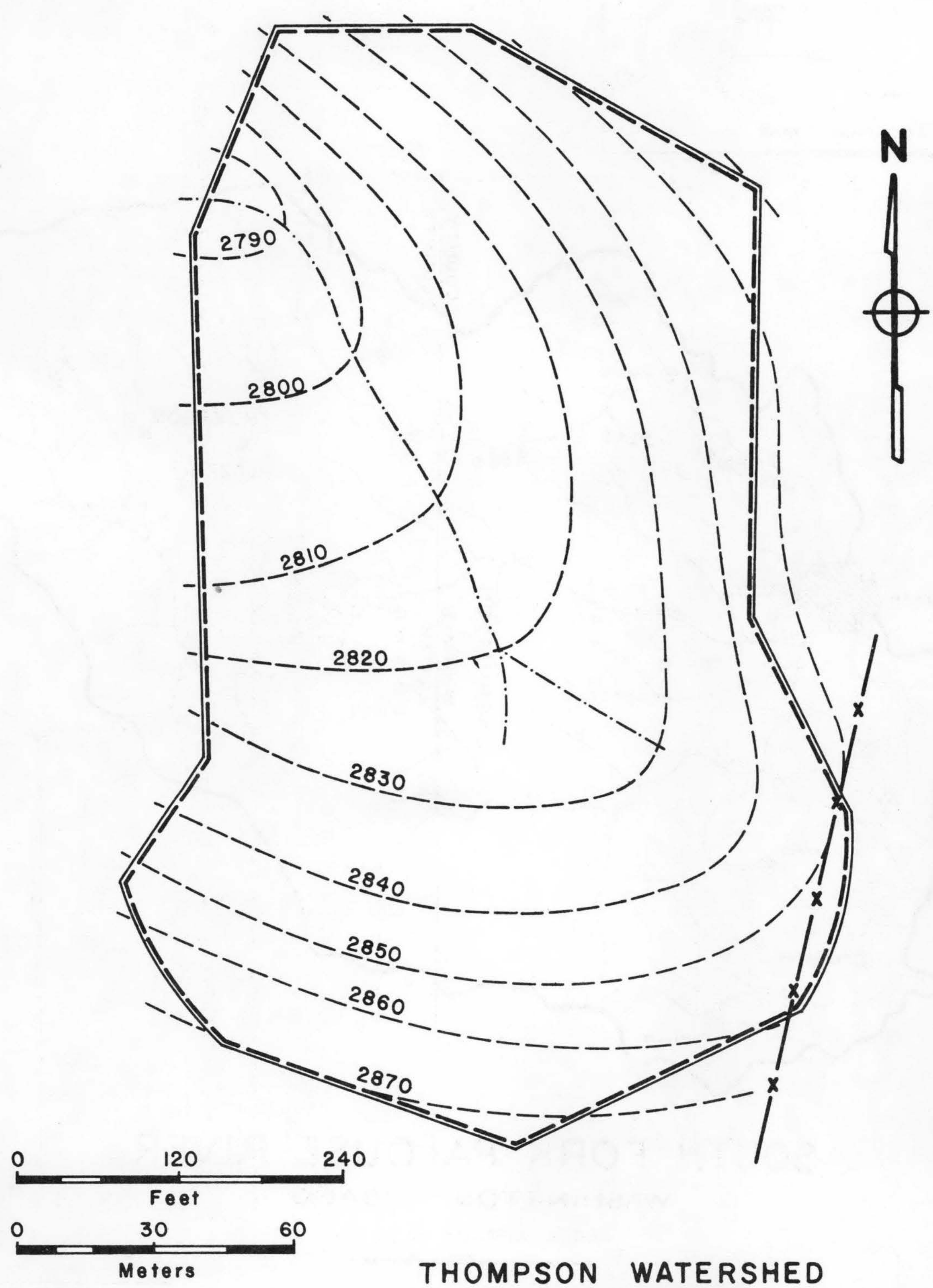

Figure 3. Pitzen watershed map

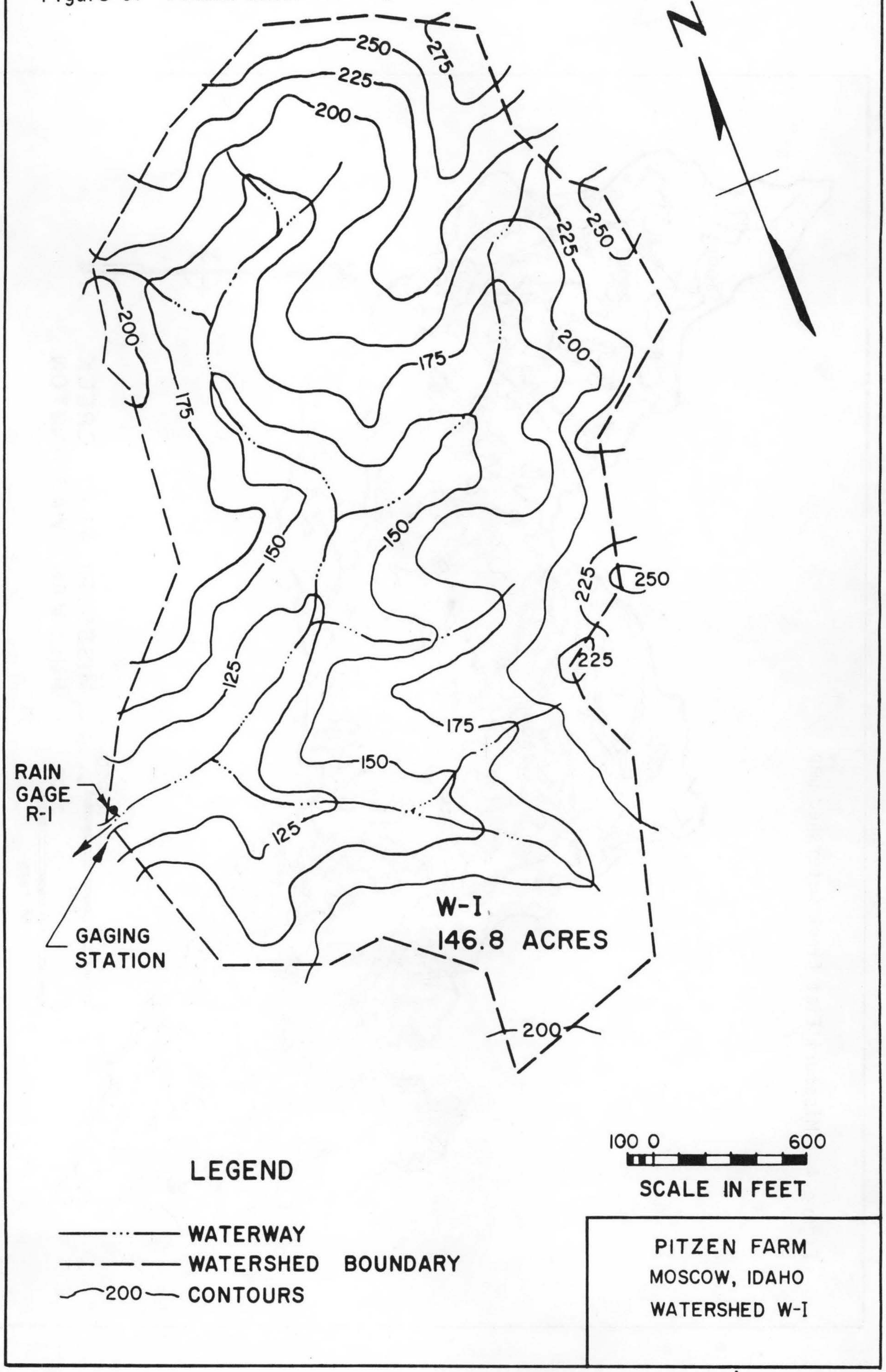

Figure 4. Missouri Flat Creek watershed map

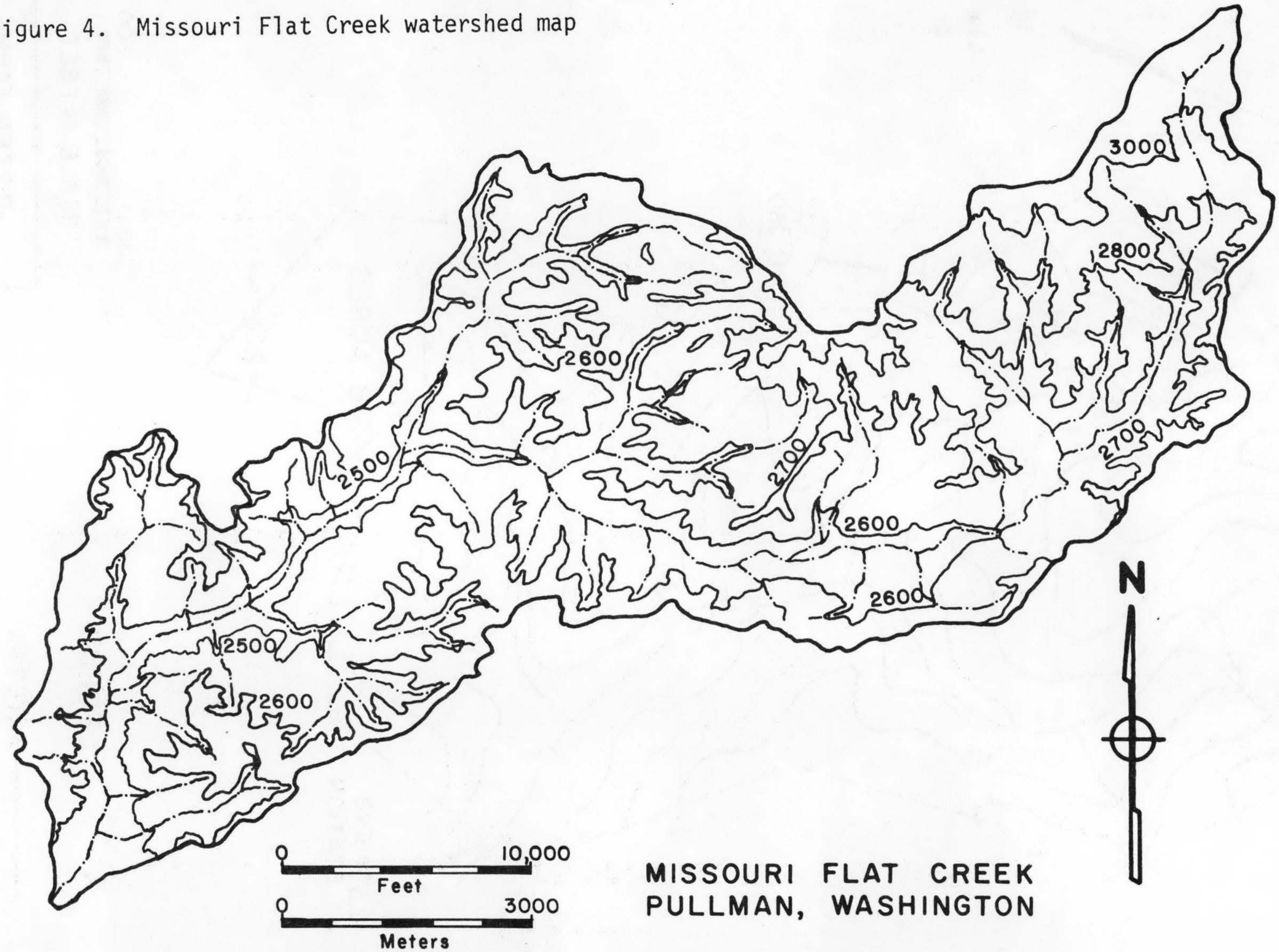

Table 1. Some characteristics of three Palouse cropland watersheds

	Area (acres)	Average Width (ft)	Slope	Soil	Crop
Missouri Flat Creek	17,600	13,000	5-30	silt loam	winter wheat peas spring grain
Pitzen Farm	146.8	1,800	5-30	silt loam	peas winter wheat
Thompson	8.2	420	15.5 (average)	silt loam	spring barley

Data such as precipitation, runoff, pan-evaporation, and daily maximum and minimum temperatures were obtained from the cited references (Potter and Love, 1942; Soil Conservation Service, 1941; Davis, 1971; Druffel, 1972; Molnau, 1975). Unfortunately, there were no recorded pan evaporation data for the winter season. Thus, it was necessary to estimate winter pan evaporation amounts for proper operation of the model. The procedure used for estimating winter pan evaporation is shown in Appendix I.

The infiltration rate was estimated to be between 0.05 to 0.1 inches per hour even though the Palouse soils are classified as in groups B and C. This low value was used considering frozen ground and low water temperature during winter time. These values were also used for the other watersheds in this study. In addition, Thompson had a cutoff wall installed to a depth of nine feet below the channel bottom at the gage site to intercept and bring any subsurface flow to the surface. The groundwater recharge rate was set at 0.0005 inches per hour.

Some necessary data such as soil and cropping data were not available for Missouri Flat Creek watershed. These data were estimated from information collected in the early 1940's under the South Fork Palouse River Demonstration Project or obtained from the SCS, Colfax, Washington.

In order to better evaluate the overland flow, small runoff plots were built by the ARS near the Palouse Soil and Water Conservation Field Station near Pullman, Washington. The plots are 6' x 50', 6' x 100' and 6' x 150' rectangles. Runoff and sediment concentrations have been collected for the 1975 and 1976 water years. It is expected that the flow from these plots will be primarily overland flow or at least in very small rills which can be assumed to behave as sheet flow. The soil erosion data will later be used to verify the erosion model in the future. However, the data from the plots were not used in this study because the data collection is not yet finished.

Program Operation

The USDAHL model was catalogued in subroutine form including the main program. Whenever a subroutine needs to be changed, it can be done by cataloguing only the revised subroutine. This process saves time and running cost by avoiding compiling all the programs. It takes approximately four minutes and 48 seconds CPU or about twenty dollars to link, edit and run the program.

Two methods are used to compare the simulated and observed runoff. One is a statistical analysis using a correlation coefficient. However, the coefficient is not good enough to explain the simulation if there are any large differences between the simulated and observed runoff for one large event even if others are fitted well. The other comparison method is graphical. The simulated and the observed hydrographs are plotted along with precipitation and temperature. This method seems to be more intuitive in explaining the results. Both methods are done through subroutines, STATS and HYDGRA with the actual plotting being done on a CALCOMP plotter.

REVISION OF USDAHL WATERSHED MODEL

As mentioned in the previous chapter, it was necessary to modify or revise the model in order to apply it to the Palouse. During revision, it was desired to minimize modification to the flowchart of the model.

It should be noted that the hydrologic conditions of the Midwest where the program was developed and tested are significantly different from those of the Palouse area.

Water Year Systems

In the Palouse a rainy season usually starts in October and ends in March or April. This originates from maritime polar Pacific air which is cool, moist and unstable, and controls the climate during the winter. There is much moisture available from snowmelt during December through April. During the summer, there is no significant precipitation until September or early October. Therefore, in early October, the A and B soil horizons are dry, there is no snow on the ground, and little or no runoff (except base flow) from a small watershed (less than 100 sq. miles). This indicates that it is useful and advantageous to start the simulation in October rather than January as used in the original model and the model was changed accordingly.

Temperature Values

It is desirable to couple the model with a reliable snowmelt routine. The original model uses a snowmelt equation but it is so simplified that it does not improve the simulation. A snowmelt model is currently being developed by a graduate student in Agricultural Engineering at the University of Idaho, however, during this study the original snowmelt procedure was used. This procedure was just separated from subroutine DATA and put into a separate subroutine (SNWMLT) of its own to make it easier to insert the new snowmelt routine when it is finished.

The original snowmelt is calculated by the following equation:

$$MELT = 0.15 * (T-30) * (1.0 - 0.5 * VEG) + 2 * P \quad \ldots\ldots \quad (1)$$

where

MELT = Potential snowmelt per day on a zone surface (inches per day)

T = Average weekly temperature (^{o}F)

VEG = Weighted average vegetative density for a zone

P = Rainfall falling in a day (inches per day)

In equation (1), 30°F is fixed to define a snowmelt event. It was modified so that any temperature can be used. The program uses a tag on the precipitation card. Thus, any precipitation known to be snow is marked by placing an 'S' after the amount of precipitation.

The model was changed so that the type of precipitation is defined through an index temperature. This index temperature was taken as 32°F. It is also known that the precipitation type depends not only on temperature but also on several other atmospheric factors. It is not unusual for snowfall to occur above 32°F, especially in the early spring.

To solve the problem caused by innacuracy of the average weekly temperature, a subroutine, TEMPTR, was developed to create time-break temperatures. A daily temperature distribution was calculated using a sinusoidal function of maximum and minimum daily temperatures and the time of the break. This time-break temperature would be better than the mean daily or average weekly temperature because it is possible to have melt during part of a day when the mean daily temperature would be below 32°F. The average weekly temperature is still used to simulate evapotranspiration and evaporation in order to use the growing index calculation, which will be useful for future soil moisture studies.

Defining Time Intervals

The main portion of the model is executed in a DO loop. Each time the loop is executed, the model time advances by a time interval, DELT. The original model uses the amount of moisture input to the model to calculate DELT so that a shorter interval is used as this moisture goes up. In the revised model, the actual moisture input is calculated in subroutine SNWMLT. DELT is the time factor used in both subroutines TEMPTR and SNWMLT. Therefore, DELT must be defined before the two subroutines are executed. The maximum potential moisture in a period, which consists of precipitation and snow water equivalent on the ground is now used as the basis of creating DELT. Henceforth the term "snow" is used in place of the term "snow water equivalent" in this report.

Subsurface Parameters

When the model was tested after the above revision, the simulations still were poor for the fall and early winter months. As shown in Figure 5, high simulated runoff occurred and matched with precipitation events in October, November, December and even on into January. A detailed check of subroutine SUBSUR revealed a potential source of the problem where soil water is apportioned to downward seepage and lateral movement to the channel.

The equation is:

$$SUBPUT_{L+1} = DELT \; * \; C_L \; * \; (G_L - SA_L) \; / \; G_L \; . \; . \; . \; . \qquad (2)$$

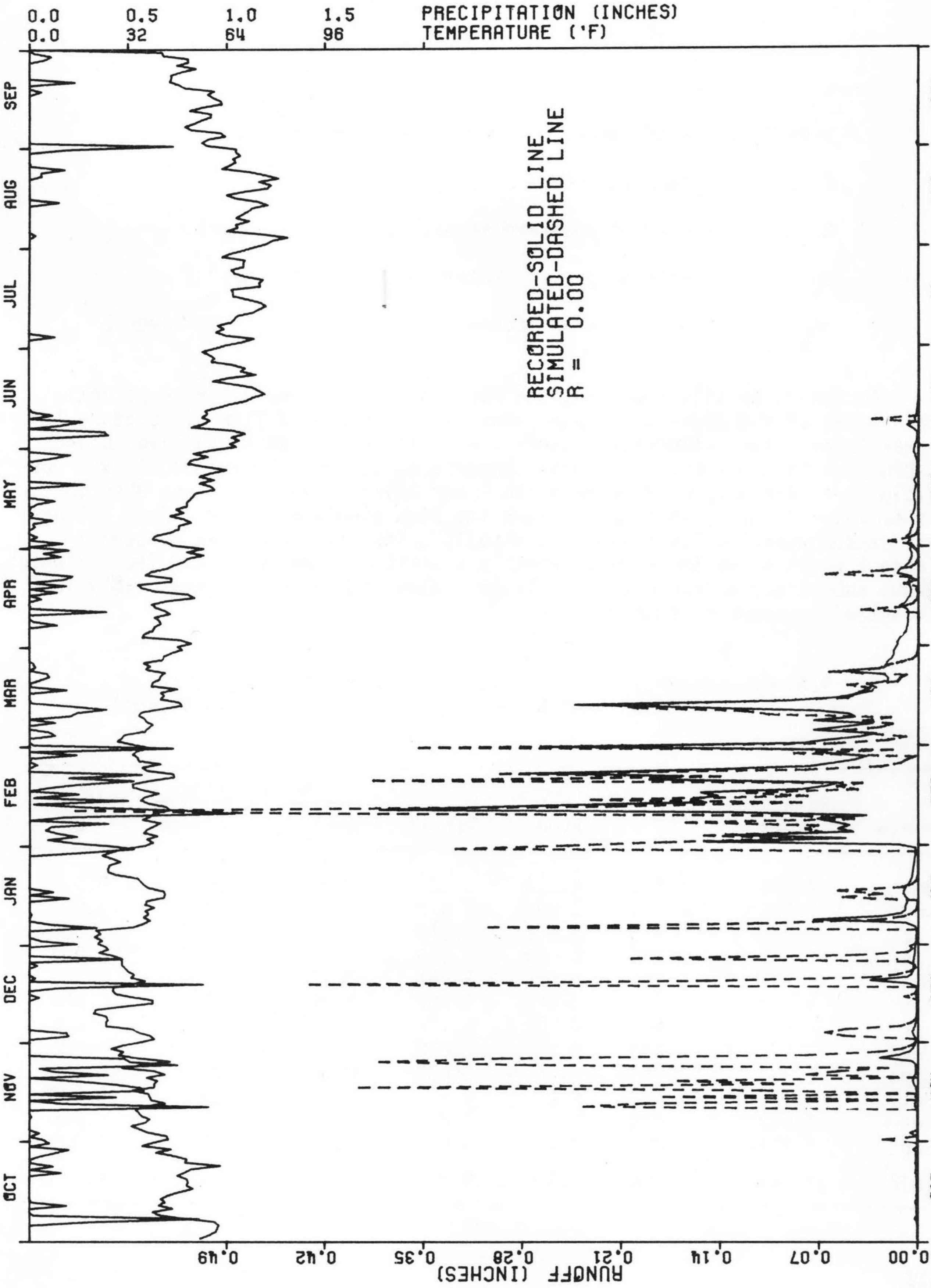

Figure 5. Comparison of observed and simulated runoff using original SUBSUR routine (Missouri Flat Creek, 1961)

where:

$SUBPUT_{L+1}$ = Water passing downward to layer L+1 (inches)

DELT = Time increment (hours)

C_L = Rate of downward seepage (inches per hour)

G_L = Free or gravity water in layer L (inches)

SA_L = Air space in inches equivalent of water in layer L.

According to this equation, the ratio of actual free water to potential free water of the upper soil layer controls the downward flow of moisture to the lower layer. The difference between the existing free water in layer L and $SUBPUT_{L+1}$ is subjected to lateral subsurface outflow. Therefore, it was possible that high lateral flow from the upper layer could take place when the lower layer is dry. This might cause the high simulated runoff after a long dry season when the lower layer is usually quite dry. This can be seen in Table 2 which shows the overall monthly distribution of water and Table 3 which shows subsurface water movement. Table 2 also indicates an unreasonably low amount of groundwater recharge.

Table 2. Summary table for 1961 Missouri Flat Creek using original SUBSUR subroutine. (All values in inches)

Month	Rain and Melt	ET	Evap.	Runoff	Return Flow Onsite	Return Flow Offsite	Gr
Oct	2.230	0.670	0.000	0.029	0.029	0.0	0.0
Nov	5.709	0.403	0.032	2.616	1.293	0.0	0.001
Dec	1.970	0.125	0.005	1.113	0.618	0.0	0.006
Jan	2.550	0.128	0.010	1.375	0.771	0.0	0.004
Feb	6.101	0.331	0.026	3.691	2.402	0.0	0.018
Mar	2.670	0.713	0.025	1.782	1.395	0.0	0.027
Apr	1.630	1.568	0.001	0.175	0.171	0.0	0.006
May	1.420	2.049	0.001	0.038	0.038	0.0	0.001
June	1.350	3.760	0.001	0.033	0.033	0.0	0.000
July	0.130	3.432	0.0	0.0	0.0	0.0	0.000
Aug	0.680	1.476	0.0	0.0	0.0	0.0	0.000
Sept	1.230	1.051	0.0	0.0	0.0	0.0	0.000
TOTAL	27.669	15.706	0.102	10.852	6.751	0.0	0.063

To solve this problem, equation (2) was changed by dropping the soil moisture terms. The new function is:

$$SUBPUT_{L+1} = DELT * C_L \quad . \ . \ . \ . \qquad (3)$$

This equation says that any water that enters the upper layer will move to the lower layer and fill its available porosity. However, this downward movement is subject to several restrictions. 1) If the free water in layer L exceed $SUBPUT_{L+1}$ then $SUBPUT_{L+1}$ fills the porosity of layer L+1 and the remainder is kept in layer L, either satisfying the available moisture capacity or becoming subject to potential lateral flow. 2) If $SUBPUT_{L+1}$ is greater than the free water in layerL, $FREE_L$, then $FREE_L$ is substituted for $SUBPUT_{L+1}$. 3) When $SUBPUT_{L+1}$ exceeds the available porosity in layer L+1, SA_{L+1}, the latter takes the place of $SUBPUT_{L+1}$. A significant improvement in the fall simulation can be seen when comparing Figure 5 with Figure 17 which was run using equation 3.

Even though the simulation was improved, equation (3) does not seem to be completely reasonable for subsurface water movement. The equations says that downward movement of subsurface water does not depend on the soil moisture condition. From another point of view, the equation also tells us the priority of subsurface free water movement is first downward, then lateral. There should be more study to justify or to modify the simulation of soil moisture movement.

Table 3. Subsurface moisture movement using original SUBSUR subroutine for Missouri Flat Creek in 1961 (in inches)

Day	Layer / Zone	Lateral Flow I	Lateral Flow II	Downward Flow I	Downward Flow II	Soil Moisture I	Soil Moisture II
Nov 15	I	0.182	0.0	0.117	0.0	2.228	6.010
	II	0.116	0.0	0.227	0.0	2.177	6.824
	III	0.966	0.0	0.623	0.0	2.436	8.487
Nov 16	I	0.468	0.0	0.310	0.0	2.188	6.320
	II	0.018	0.0	0.690	0.0	2.173	7.514
	III	2.007	0.0	1.281	0.0	2.242	9.768
Nov 17	I	0.160	0.0	0.100	0.0	2.343	6.420
	II	0.039	0.0	0.346	0.0	2.203	7.861
	III	0.623	0.0	0.410	0.0	2.443	10.178
Nov 18	I	0.171	0.0	0.226	0.0	2.178	6.646
	II	0.033	0.0	0.240	0.0	2.164	8.101
	III	0.410	0.0	0.556	0.0	2.340	10.733
Nov 19	I	0.162	0.0	0.137	0.0	2.248	6.783
	II	0.066	0.0	0.291	0.0	2.177	8.392
	III	0.653	0.0	0.709	0.0	2.440	11.589
Nov 20	I	0.075	0.0	0.093	0.0	2.184	6.875
	II	0.027	0.0	0.081	0.0	2.174	8.473
	III	0.556	0.039	0.632	0.001	2.219	12.181
Nov 21	I	0.016	0.0	0.011	0.0	2.197	6.886
	II	0.012	0.0	0.024	0.0	2.177	8.497
	III	0.101	0.142	0.064	0.002	2.265	12.101
Nov 22	I	0.341	0.0	0.229	0.0	2.362	7.114
	II	0.078	0.0	0.626	0.0	2.208	9.123
	III	0.881	0.150	0.559	0.003	2.446	12.505
	Maximum available water capacity (in inches)						
	I	2.178	11.970				
	II	2.178	11.970				
	III	2.178	11.970				

INPUT DATA

The input parameters required in the model are composed of watershed parameters, soil and crop data, and routing coefficients (channel and subsurface). Technical Bulletin 1518 (Holtan and others, 1975) describes the above in more detail.

In the revised model some additional data are required. Three input options were designed to control the model output: a) daily output in subroutine POLLUT, b) statistical comparison of simulated and observed daily flows and c) graphical comparisons of precipitation, temperature and simulated and ovserved runoff. When option b is used, the observed runoff must be inserted. Also, option c cannot be used along, so if option c is specified, then option b must also be specified.

An index card includes six indices which are used to define several conditions. These indices are: base temperatures for precipitation type, snowmelt, evapotranspiration and frozen ground, and the times of a day when maximum and minimum temperatures occur. Daily maximum and minimum temperatures instead of mean weekly temperatures are required by the revised program.

The watersheds tested in this study have similar soil parameters such as available water holding capacity (AWC), water drained by gravity (G), and infiltration rate (FC) from B horizon (Appendices 4, 5 and 6). Soil moisture tension data are available from an ARS compilation (Holtan and others, 1968). These data are recommended for obtaining AWC, G and percent of soil cracking if specific data for the locations are not available. Neff (1966) and Davis (1971) collected soil moisture tension data for Thompson watershed. Davis (1971) found a total moisture capacity of 5.2 inches per foot at 1/3 atmosphere tension and 2.3 inches per foot at 15 atmosphere tension. This indicates that the soil from Thompson watershed has a high water holding capacity.

Groundwater recharge in the Palouse has been studied by several researchers (Bloomsburg, 1959; Ross, 1965; Laney and others, 1923; Packer, 1955; Stevens, 1960; Davis and Molnau, 1973). The procedure used by these researchers is based on the water balance equation.

$$\text{GW recharge} = \text{Precipitation} - \text{Runoff} - \text{Evapotranspiration} - \text{Change in Soil Moisture Storage} \quad (4)$$

In this equation, runoff and ET are the factors which have the greatest effect on the amount of groundwater recharge. The researchers showed that the groundwater recharge varied from 5% to 35% of the total annual precipitation. A mean value was used for early simulation and revised as necessary based on the model output.

The infiltration rate is one of the most critical input parameters. The infiltration rate is defined to be the rate at which water enters the surface of the soil and which is controlled by surface conditions (Musgrave, 1955).

It is determined by the nature of the soil and its conditions, the nature of the storm and the season of the year. The soils, as defined by Soil Conservation Service, are divided into four infiltration groups A, B, C and D (Soil Conservation Service, 1972). This tabulation shows the Palouse soils are in groups B and C, which have an infiltration rate of 0.15 to 0.30 inches per hour and 0.05 to 0.15 inches per hour, respectively. As Musgrave pointed out, the infiltration rate is very much dependent on the water with a nearly perfect correlation between infiltration and viscosity of water. Infiltration tends to be higher in the warm months than the cool months. Because of the significant runoff in the winter months, the infiltration rate should be determined considering the low temperatures, high soil moisture content and occasional frozen ground.

Infiltration and precipitation excess are computed for each soil zone by comparing observed rainfall or snowmelt to the infiltration capacities computed by the following equation:

$$f = GI * a * Sa^{1.4} + f_c \tag{5}$$

where

f = infiltration capacity (inches per hour)

a = infiltration in inches per hour per inch$^{1.4}$ ov available storage (index of surface-connected porosity)

Sa = available storage in the surface layer (inches)

f_c = constant rate of infiltration after prolonged wetting (inches per hour)

GI = Growth index of crop in percent of maturity.

This equation represents the sum of products of velocities and cross sections in flow tubes. Details of the infiltration theory used in the model are described more fully by Holtan and others (1975). When high infiltration rates are used for f_c little overland flow is generated. An estimated value is used and modified as needed.

Channel flows and subsurface return flows are routed by the simultaneous solution of the continuity equation and storage function. Storage coefficients are obtained by integration of the flow recession curve for a given watershed. Figures 6, 7 and 8 show recession flows plotted on semilogarithmic paper for the study watersheds. Also shown are the routing coefficients as used in this study. This technique is that used by Holtan and others (1975).

The model revises the routing coefficients for the upper two regimes from soil information based on watershed size, since as the size diminishes, the importance of detail increases. The equation used to recalculate the coefficients is:

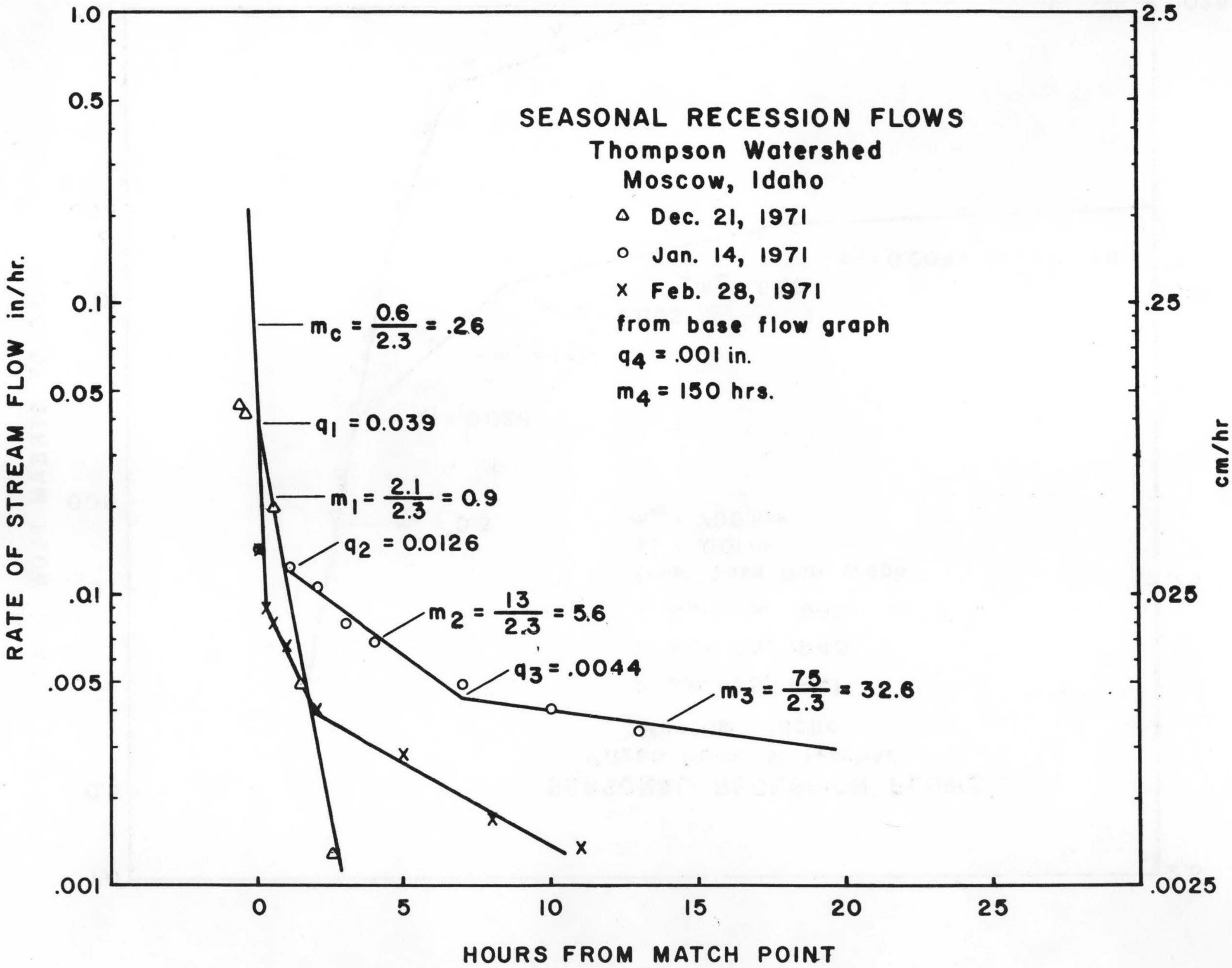

Figure 6. Recession curves and regime separations (Thompson watershed)

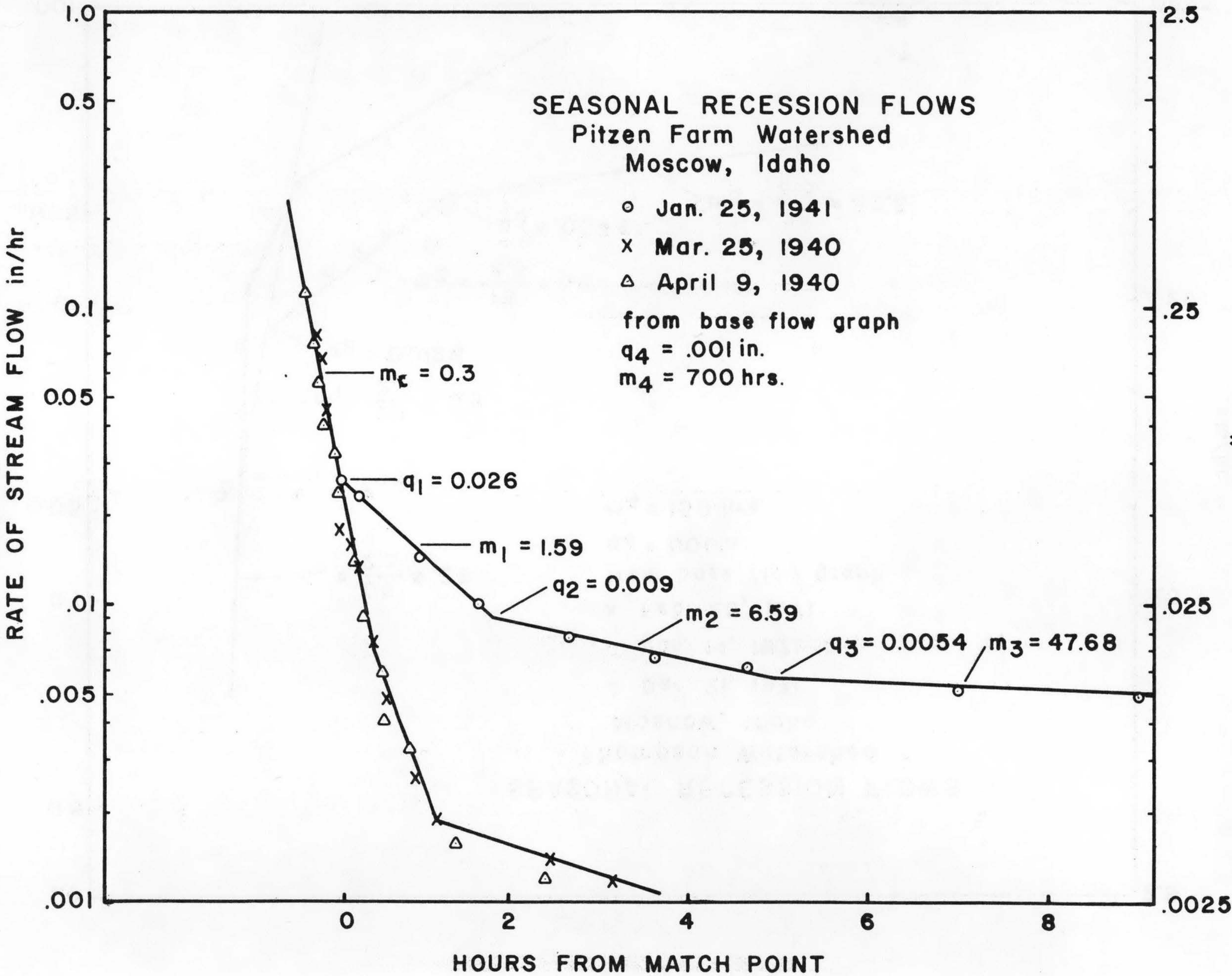

Figure 7. Recession curves and regime separations (Pitzen farm watershed)

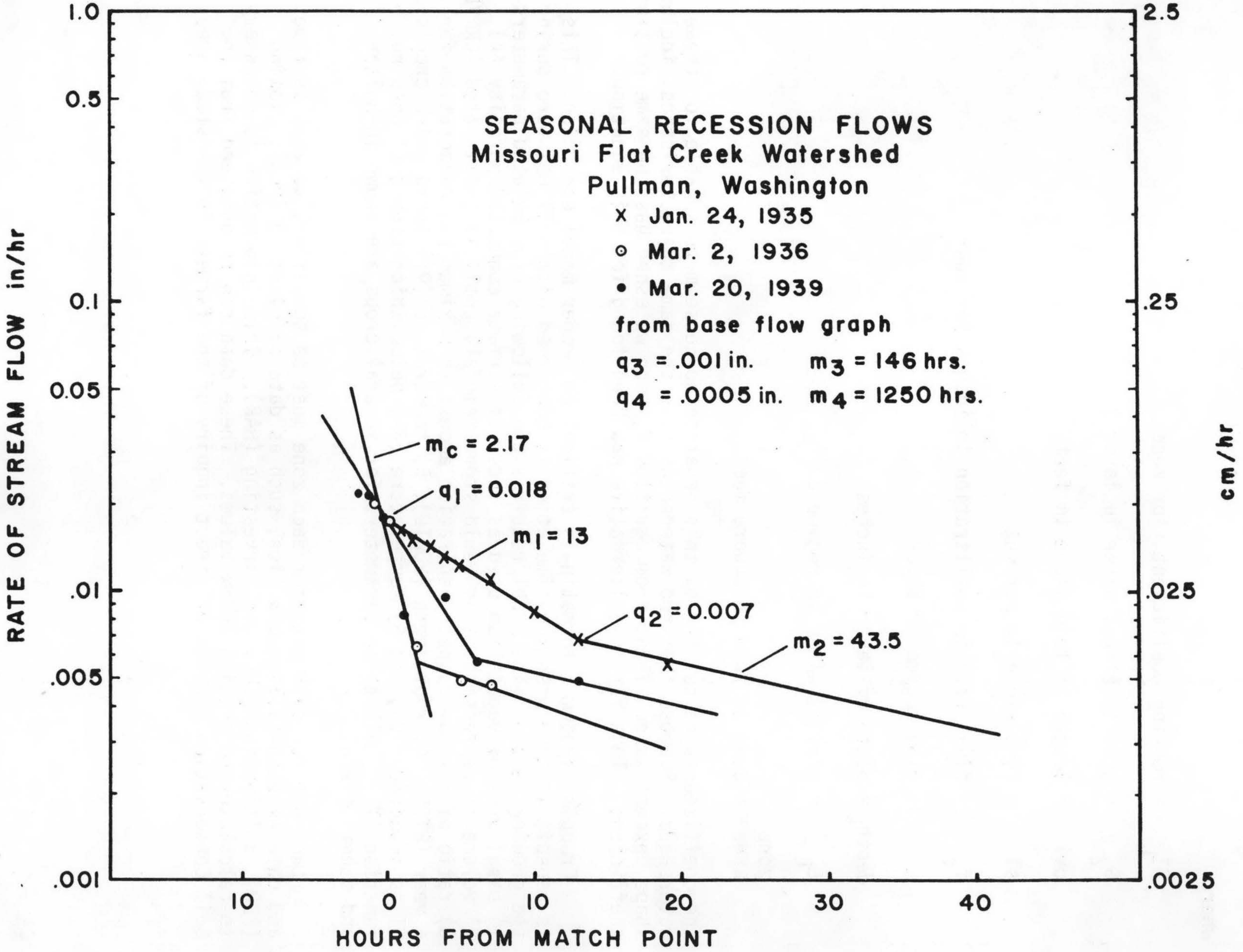

Figure 8. Recession curves and regime separations (Missouri Flat Creek watershed)

$$MZ_L = depth_L * G_2^2 * ovl^2 * (sl^2 + 1)^{0.5}/(f_c * G_L * \text{Zone area} * sl) \quad (6)$$

where

MZ_L = routing coefficient for zone

G_2 = gravity (free) water in layer 2

ovl = length of land slope in feet

sl = land slope in percent

f_c = final rate in infiltration in inches per hour

L = flow regime or layer

$depth_L$ = depth of layer in inches

G_L = gravity water in regime L

zone area = area of zone in square feet

The coefficients calculated by this equation do no seem reasonable for these watersheds. Suppose that two watersheds have the same characteristics, including shape, except size. Then, from equation 6, each wateshed has the same routing coefficient. Thus far, no alternative has been found for this equation.

Cropping system informatin is critical to proper model operation. This is especially true when the simulation is concerned with soil moisture during the growing season. The model requires the following crop related parameters: 1) basal area of vegetation used as index of surface connected porosity (A), 2) volume of depressions that would store rainfall until it infiltrated (CRPVD), 3) ratio of maximum evapotranspiration amount to maximum pan evaporation for a year (ETEP), 4) root depth (ROOTD), 5) temperature (^oF) above which crop's ET is impaired (TU), and 6) temperature (^oF) below which crop's ET does not function (TL). All these parameters for several crops are shown in Holtan and others (1975).

Land use for each year for each zone must be specified, as well as type and date of each tillage practice, such as date of planting (PLA), plowing (PLO), cultivating (CUL) and harvesting (HAR). This information is necessary to calculate the growing index values. These data can be obtained from the Soil Conservation Service or direct inquiry of the farmers in the study area.

APPLICATION AND RESULTS

It was mentioned that three different size watersheds were used to evaluate the USDAHL model. The input parameters and climatologic data were collected for each watershed. All the results discussed in this chapter are best fit hydrographs obtained after several program runs.

Thompson Watershed Results

This watershed is located on the eastern edge of the Palouse about six miles northeast of Moscow, Idaho. The watershed is oval in shape (shape factor (area/length^2) of .51) covering 8.2 acres at elevations of 2790 feet to 2870 feet. Average slope is 15.5 percent (Druffel, 1974). The watershed is evenly divided into north and southwesterly facing segments. No permanent stream channel exists because of continuous cropping on the area.

The soil is basically a silt loam with a depth of approximately five feet to a layer of restricted permeability (Neff, 1966) with 9" of topsoil. This watershed receives slightly more rainfall than other segments of the Palouse region to the west. The area has been planted to spring barley. The barley was usually planted in late April or early May, harvested in August, and the ground is then plowed.

Only one zone was used since the watershed is small and no permanent channel exists. Storm hydrographs were obtained from unpublished data prepared by Davis (1971) and Druffel (1974).

Based on the data of Neff (1966) and Davis (1971), the available water holding capacity (AWC) and gravitational water capacity (G) for the watershed were 24.2% and 11.7% in the A horizon, and 24.2% and 6.7% in the B horizon. The values for the A horizon were also adopted for other watersheds used in this study assuming that they have the same soil characteristics. The initial available soil moisture (ASM) is estimated as the soil moisture on September 30. If the first simulated runoff caused by subsurface flow is faster and/or higher than the observed runoff, ASM should be reduced. The available soil moisture for each year for each zone and layer is calculated and printed for the year. Therefore, only the beginning year of a simulation run needs to be estimated.

Routing coefficients for the A and B layers were calculated by the model using equation 6. As shown in equation 6, the routing coefficients of the upper two layers depend on the square of the overland flow length. For Thompson watershed, an overland flow length of 180 feet was used even though the actual average width is about 420 feet.

The input parameters for the Thompson watershed are shown in Appendix 4. These are the values actually used by the model for the Thompson watershed. Appendix 4 also shows the summarized results of 1971 and 1972 including a water balance. The monthly simulated values of 1971 compare poorly with observed values, but 1972 was better.

Table 4 and Figure 9 show the monthly and annual water movement on the watershed. The annual total simulated runoff of 5.4 inches for 1971 and 11.1 inches for 1972 are comparable with the observed values of 6.1 and 11.5 inches. The annual total is controlled by pan evaporation data, groundwater recharge rate and initial soil moisture (ASM).

Figures 10 and 11 show a graphical comparison of the observed and simulated daily runoff results while Tables 5 and 6 give a listing of the winter runoff season.

Some observations of the data are:

1. The simulation for 1971 water year (Table 5) is acceptable except some events which result from poor snowmelt and frozen ground effects.

2. The events of days 133, 134 and 135 are reliable, but higher than observed possibly because of high snowmelt on day 133. A similar event is on days 158 and 159. The high observed runoff on day 174 was not simulated. The abrupt decreasing in runoff on the following day indicates that the runoff occurred as overland flow with a higher amount of snowmelt than was simulated.

3. The three high observed peaks of 1972 seem to be generated by snowmelt or rain-on-snow because of high temperature and rainfall on those dates. As shown in Table 6. There are three high runoff events (more than 1 inch per day) observed in 1972. The first event (day 112) was a rain-on-snow event whose volume was reasonably simulated by the model but seems to have removed the available snow on day 111 from the watershed too fast. The observed event on day 139 was simply not simulated at all. The reasons for this are not apparent but could be caused by a combined effect of frozen ground and high snowmelt.

Pitzen Farm Watershed

The Pitzen watershed is located northeast of Moscow, Idaho. The watershed has a shape factor of 0.59 and covers 146.8 acres at elevations of 2650 feet to 2850 feet. Three years of data (1938, 1939 and 1940) were used. Each year has different climatological conditions. The 1939 year is relatively dry (16 inches of precipitation) moderate in 1938 (19.67 inches) and heavy precipitation occurred in 1940 (24.58 inches).

The watershed was divided into three zones. The main factors considered in defining the zones were slope and location. The first zone is the upland (10% average slope), the intermediate area is the second zone (17% average slope) and the bottom land, alluvium, was assigned to zone 3 (5% average slope).

Table 4. Monthly summary of water movement - Thompson watershed

Year	Month	Precip.	Rain and Melt	ET	GW Recharge	Observed Runoff	Simulated Runoff
1970	Oct	1.48	1.480	0.467	0.0	0.0	0.0
	Nov	2.66	2.157	0.422	0.0	0.0	0.140
	Dec	1.52	1.321	0.106	0.0	0.0	0.010
1971	Jan	2.98	3.681	0.152	0.198	3.11	2.255
	Feb	1.87	1.640	0.247	0.241	0.75	1.159
	Mar	1.53	1.760	0.653	0.257	2.05	0.947
	Apr	1.15	1.150	2.986	0.010	0.0	0.001
	May	1.75	1.750	1.211	0.0	0.0	0.011
	June	3.65	3.650	1.891	0.209	0.38	0.900
	July	0.65	0.650	4.330	0.0	0.0	0.0
	Aug	1.13	1.130	1.565	0.0	0.0	0.0
	Sep	1.58	1.580	0.375	0.0	0.0	0.0
Total		21.95	21.950	14.405	0.915	6.130	5.424
	Oct	1.22	1.080	0.814	0.0	0.0	0.002
	Nov	2.72	2.860	0.486	0.0	0.0	0.051
	Dec	4.31	3.418	0.129	0.174	0.0	1.865
1972	Jan	3.40	3.905	0.090	0.369	3.543	3.476
	Feb	2.72	3.107	0.351	0.288	4.315	2.399
	Mar	4.06	4.060	0.803	0.372	3.611	3.155
	Apr	0.99	0.990	2.850	0.000	0.015	0.011
	May	2.38	2.380	1.989	0.0	0.0	0.110
	June	0.43	0.430	2.267	0.0	0.0	0.0
	July	0.83	0.830	2.216	0.0	0.0	0.0
	Aug	0.60	0.600	0.791	0.0	0.0	0.0
	Sep	0.70	0.700	0.096	0.0	0.0	0.0
Total		24.36	24.360	12.880	1.204	11.484	11.070

Note: All values are in inches

Table 5. Daily summary of some rainy and snowmelt seasons (Thompson watershed in 1971)

DAILY SUMMARIES OF SNOW FOR YEAR 1971

	PRECIPITATION(IN)			TEMPERATURE(F)			SWE ON	AVAILABLE MOISTURE(IN)			SIMULATED RUNOFF		OBSERVED RUNOFF	
DAY	RAIN	SNOW	TOT	MAX	MIN	MEAN	GROUND	RAIN	SNOW	TOTAL	(IN)	(CFS)	(IN)	(CFS)
111	0.55	0.0	0.55	47.	34.	40.5	0.0	0.550	0.0	0.550	0.2535	0.0873	0.4000	0.1378
112	0.0	0.0	0.0	35.	30.	32.5	0.0	0.0	0.0	0.0	0.1824	0.0628	0.1800	0.0620
113	0.0	0.0	0.0	33.	22.	27.5	0.0	0.0	0.0	0.0	0.0644	0.0222	0.0500	0.0172
114	0.22	0.33	0.55	36.	22.	29.0	0.0	0.220	0.330	0.550	0.3674	0.1266	0.0200	0.0069
115	0.0	0.0	0.0	38.	34.	36.0	0.0	0.0	0.0	0.0	0.1075	0.0370	0.0400	0.0138
116	0.0	0.0	0.0	38.	35.	36.5	0.0	0.0	0.0	0.0	0.0414	0.0143	0.0900	0.0310
117	0.05	0.0	0.05	39.	36.	37.5	0.0	0.050	0.0	0.050	0.0280	0.0096	0.1900	0.0655
118	0.04	0.0	0.04	47.	35.	41.0	0.0	0.040	0.0	0.040	0.0335	0.0115	0.1600	0.0551
119	0.0	0.0	0.0	45.	35.	40.0	0.0	0.0	0.0	0.0	0.0232	0.0080	0.0800	0.0276
120	0.0	0.0	0.0	48.	34.	41.0	0.0	0.0	0.0	0.0	0.0180	0.0062	0.0500	0.0172
121	0.0	0.0	0.0	50.	36.	43.0	0.0	0.0	0.0	0.0	0.0135	0.0047	0.0300	0.0103
122	0.0	0.0	0.0	54.	46.	50.0	0.0	0.0	0.0	0.0	0.0098	0.0034	0.0200	0.0069
123	0.0	0.0	0.0	57.	39.	48.0	0.0	0.0	0.0	0.0	0.0066	0.0023	0.0200	0.0069
124	0.0	0.0	0.0	53.	34.	43.5	0.0	0.0	0.0	0.0	0.0038	0.0013	0.0100	0.0034
125	0.0	0.0	0.0	38.	25.	31.5	0.0	0.0	0.0	0.0	0.0015	0.0005	0.0100	0.0034
126	0.0	0.0	0.0	34.	20.	27.0	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0100	0.0034
127	0.0	0.29	0.29	36.	19.	27.5	0.26	0.0	0.033	0.033	0.0	0.0	0.0	0.0
128	0.0	0.0	0.0	31.	10.	20.5	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
129	0.0	0.0	0.0	29.	8.	18.5	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130	0.0	0.0	0.0	32.	18.	25.0	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
131	0.0	0.0	0.0	36.	19.	27.5	0.21	0.0	0.048	0.048	0.0	0.0	0.0	0.0
132	0.0	0.36	0.36	33.	28.	30.5	0.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0
133	0.10	0.45	0.55	45.	32.	38.5	0.20	0.100	0.818	0.918	0.3250	0.1120	0.3200	0.1102
134	0.0	0.0	0.0	49.	32.	40.5	0.0	0.0	0.201	0.201	0.3381	0.1165	0.2100	0.0723
135	0.0	0.0	0.0	55.	40.	47.5	0.0	0.0	0.0	0.0	0.1660	0.0572	0.0800	0.0276
136	0.0	0.0	0.0	49.	38.	43.5	0.0	0.0	0.0	0.0	0.0578	0.0199	0.0400	0.0138
137	0.0	0.0	0.0	48.	38.	43.0	0.0	0.0	0.0	0.0	0.0210	0.0072	0.0500	0.0172
138	0.0	0.0	0.0	41.	32.	36.5	0.0	0.0	0.0	0.0	0.0138	0.0048	0.0200	0.0069
139	0.0	0.0	0.0	44.	30.	37.0	0.0	0.0	0.0	0.0	0.0100	0.0034	0.0100	0.0034
140	0.0	0.0	0.0	47.	31.	39.0	0.0	0.0	0.0	0.0	0.0067	0.0023	0.0100	0.0034
141	0.08	0.08	0.16	45.	30.	37.5	0.08	0.080	0.0	0.080	0.0040	0.0014	0.0100	0.0034
142	0.0	0.0	0.0	34.	23.	28.5	0.08	0.0	0.0	0.0	0.0016	0.0006	0.0100	0.0034
143	0.0	0.0	0.0	40.	18.	29.0	0.0	0.0	0.080	0.080	0.0202	0.0070	0.0	0.0
144	0.0	0.0	0.0	38.	26.	32.0	0.0	0.0	0.0	0.0	0.0093	0.0032	0.0	0.0
145	0.0	0.0	0.0	37.	28.	32.5	0.0	0.0	0.0	0.0	0.0021	0.0007	0.0	0.0
146	0.0	0.0	0.0	40.	29.	34.5	0.0	0.0	0.0	0.0	0.0002	0.0001	0.0	0.0
147	0.10	0.18	0.28	46.	27.	36.5	0.0	0.100	0.180	0.280	0.1139	0.0392	0.0	0.0
148	0.0	0.0	0.0	36.	23.	29.5	0.0	0.0	0.0	0.0	0.0463	0.0160	0.0	0.0
149	0.0	0.03	0.03	32.	22.	27.0	0.03	0.0	0.0	0.0	0.0103	0.0035	0.0	0.0
150	0.0	0.06	0.06	32.	14.	23.0	0.09	0.0	0.0	0.0	0.0049	0.0017	0.0	0.0
151	0.0	0.14	0.14	30.	14.	22.0	0.23	0.0	0.0	0.0	0.0024	0.0008	0.0	0.0
152	0.0	0.0	0.0	27.	9.	18.0	0.23	0.0	0.0	0.0	0.0004	0.0001	0.0	0.0
153	0.0	0.01	0.01	32.	15.	23.5	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0
154	0.0	0.07	0.07	34.	24.	29.0	0.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0
155	0.0	0.0	0.0	35.	13.	24.0	0.30	0.0	0.014	0.014	0.0	0.0	0.0	0.0
156	0.0	0.0	0.0	32.	22.	27.0	0.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
157	0.0	0.0	0.0	34.	21.	27.5	0.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
158	0.35	0.0	0.35	39.	28.	33.5	0.0	0.350	0.296	0.646	0.1457	0.0502	0.0	0.0
159	0.0	0.0	0.0	39.	27.	33.0	0.0	0.0	0.0	0.0	0.2293	0.0790	0.0	0.0
160	0.0	0.0	0.0	42.	28.	35.0	0.0	0.0	0.0	0.0	0.0575	0.0198	0.0	0.0
161	0.26	0.0	0.26	39.	31.	35.0	0.0	0.260	0.0	0.260	0.0380	0.0131	0.0	0.0
162	0.12	0.02	0.15	39.	31.	35.0	0.02	0.125	0.0	0.125	0.0872	0.0300	0.0100	0.0034
163	0.0	0.04	0.04	40.	32.	36.0	0.0	0.0	0.065	0.065	0.0630	0.0217	0.2700	0.0930
164	0.0	0.0	0.0	34.	23.	28.5	0.0	0.0	0.0	0.0	0.0265	0.0091	0.2000	0.0689
165	0.0	0.0	0.0	33.	21.	27.0	0.0	0.0	0.0	0.0	0.0172	0.0059	0.1000	0.0345

Table 5 continued

DAILY SUMMARIES OF SNOW FOR YEAR 1971

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
166	0.0	0.0	0.0	35.	23.	29.0	0.0	0.0	0.0	0.0	0.0129	0.0044	0.0600	0.0207
167	0.0	0.0	0.0	42.	18.	30.0	0.0	0.0	0.0	0.0	0.0092	0.0032	0.0400	0.0138
168	0.0	0.0	0.0	36.	15.	25.5	0.0	0.0	0.0	0.0	0.0061	0.0021	0.0200	0.0069
169	0.0	0.0	0.0	42.	18.	30.0	0.0	0.0	0.0	0.0	0.0034	0.0012	0.0200	0.0069
170	0.0	0.0	0.0	46.	28.	37.0	0.0	0.0	0.0	0.0	0.0011	0.0004	0.0300	0.0103
171	0.0	0.0	0.0	46.	28.	37.0	0.0	0.0	0.0	0.0	0.0000	0.0000	0.1100	0.0379
172	0.0	0.0	0.0	42.	27.	34.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1000	0.0345
173	0.09	0.06	0.15	37.	29.	33.0	0.0	0.086	0.064	0.150	0.0	0.0	0.0700	0.0241
174	0.17	0.0	0.17	47.	35.	41.0	0.0	0.170	0.0	0.170	0.0153	0.0053	0.4100	0.1412
175	0.0	0.0	0.0	46.	32.	39.0	0.0	0.0	0.0	0.0	0.0287	0.0099	0.0300	0.0103
176	0.10	0.0	0.10	45.	28.	36.5	0.0	0.100	0.0	0.100	0.0068	0.0023	0.0900	0.0310
177	0.16	0.06	0.23	53.	32.	42.5	0.0	0.165	0.065	0.230	0.1289	0.0444	0.1800	0.0620
178	0.0	0.0	0.0	39.	31.	35.0	0.0	0.0	0.0	0.0	0.0402	0.0139	0.0400	0.0138
179	0.0	0.0	0.0	42.	28.	35.0	0.0	0.0	0.0	0.0	0.0132	0.0046	0.0300	0.0103
180	0.0	0.0	0.0	51.	38.	44.5	0.0	0.0	0.0	0.0	0.0084	0.0029	0.0200	0.0069
181	0.0	0.0	0.0	43.	31.	37.0	0.0	0.0	0.0	0.0	0.0054	0.0019	0.0100	0.0034
182	0.0	0.0	0.0	42.	28.	35.0	0.0	0.0	0.0	0.0	0.0028	0.0010	0.0100	0.0034
183	0.0	0.0	0.0	49.	27.	38.0	0.0	0.0	0.0	0.0	0.0007	0.0002	0.0	0.0
184	0.0	0.0	0.0	49.	31.	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
185	0.0	0.0	0.0	50.	26.	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
186	0.0	0.0	0.0	58.	30.	44.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
187	0.0	0.0	0.0	66.	40.	53.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
188	0.14	0.0	0.14	67.	41.	54.0	0.0	0.140	0.0	0.140	0.0	0.0	0.0	0.0
189	0.0	0.03	0.03	45.	29.	37.0	0.0	0.0	0.030	0.030	0.0	0.0	0.0	0.0
190	0.0	0.0	0.0	57.	29.	43.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
191	0.20	0.0	0.20	62.	31.	46.5	0.0	0.200	0.0	0.200	0.0	0.0	0.0	0.0
192	0.0	0.05	0.05	44.	30.	37.0	0.0	0.0	0.050	0.050	0.0	0.0	0.0	0.0
193	0.04	0.0	0.04	44.	26.	35.0	0.0	0.040	0.0	0.040	0.0	0.0	0.0	0.0
194	0.0	0.0	0.0	48.	26.	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
195	0.0	0.0	0.0	60.	37.	48.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
196	0.0	0.0	0.0	60.	33.	46.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
197	0.0	0.0	0.0	46.	28.	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
198	0.0	0.0	0.0	51.	26.	38.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
199	0.14	0.0	0.14	41.	33.	37.0	0.0	0.140	0.0	0.140	0.0	0.0	0.0	0.0
200	0.0	0.0	0.0	49.	33.	41.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
201	0.0	0.0	0.0	59.	31.	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
202	0.0	0.0	0.0	55.	34.	44.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
203	0.0	0.0	0.0	51.	33.	42.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
204	0.0	0.0	0.0	45.	31.	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
205	0.15	0.05	0.20	38.	33.	35.5	0.05	0.150	0.0	0.150	0.0	0.0	0.0	0.0
206	0.0	0.28	0.28	35.	31.	33.0	0.30	0.0	0.026	0.026	0.0	0.0	0.0	0.0
207	0.0	0.07	0.07	58.	30.	44.0	0.0	0.0	0.374	0.374	0.0	0.0	0.0	0.0
208	0.0	0.0	0.0	59.	33.	46.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
209	0.0	0.0	0.0	60.	40.	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
210	0.0	0.0	0.0	56.	36.	46.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
211	0.0	0.0	0.0	54.	36.	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
212	0.0	0.0	0.0	66.	35.	50.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
213	0.0	0.0	0.0	77.	43.	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
214	0.0	0.0	0.0	80.	50.	65.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
215	0.0	0.0	0.0	75.	49.	62.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
216	0.0	0.0	0.0	61.	45.	53.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
217	0.0	0.0	0.0	51.	39.	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
218	0.0	0.0	0.0	67.	39.	53.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
219	0.0	0.0	0.0	74.	50.	62.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
220	0.0	0.0	0.0	68.	47.	57.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6. Daily summary of some rainy and snowmelt seasons (Thompson watershed in 1972)

DAILY SUMMARIES OF SNOW FOR YEAR 1972

DAY	PRECIPITATION(IN)			TEMPERATURE(F)			SWE ON GROUND	AVAILABLE MOISTURE(IN)			SIMULATED RUNOFF		OBSERVED RUNOFF	
	RAIN	SNOW	TOT	MAX	MIN	MEAN		RAIN	SNOW	TOTAL	(IN)	(CFS)	(IN)	(CFS)
56	0.0	0.01	0.01	41.	31.	36.0	0.0	0.0	0.010	0.010	0.0	0.0	0.0	0.0
57	0.22	0.47	0.70	36.	32.	34.0	0.27	0.225	0.200	0.425	0.0251	0.0087	0.0	0.0
58	0.0	0.0	0.0	46.	32.	39.0	0.0	0.0	0.275	0.275	0.0	0.0	0.0	0.0
59	0.46	0.10	0.56	36.	33.	34.5	0.0	0.460	0.100	0.560	0.0129	0.0044	0.0	0.0
60	0.29	0.0	0.29	39.	34.	36.5	0.0	0.290	0.0	0.290	0.0025	0.0009	0.0	0.0
61	0.0	0.0	0.0	38.	30.	34.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	0.0	0.0	0.0	36.	28.	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	35.	31.	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	0.0	0.05	0.05	36.	21.	28.5	0.00	0.0	0.048	0.048	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	32.	27.	29.5	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	0.10	0.31	0.42	42.	29.	35.5	0.31	0.105	0.002	0.107	0.0	0.0	0.0	0.0
67	0.0	1.15	1.15	32.	6.	19.0	1.46	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	0.0	0.0	0.0	23.	0.	11.5	1.46	0.0	0.0	0.0	0.0	0.0	0.0	0.0
69	0.0	0.55	0.55	31.	14.	22.5	2.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	34.	26.	30.0	2.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71	0.0	0.05	0.05	32.	22.	27.0	2.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72	0.0	0.0	0.0	25.	11.	18.0	2.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73	0.0	0.0	0.0	31.	22.	26.5	2.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74	0.0	0.23	0.23	29.	22.	25.5	2.29	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.45	0.45	33.	25.	29.0	2.74	0.0	0.0	0.0	0.0	0.0	0.0	0.0
76	0.0	0.05	0.05	29.	6.	17.5	2.79	0.0	0.0	0.0	0.0	0.0	0.0	0.0
77	0.26	0.14	0.40	35.	13.	24.0	2.40	0.256	0.544	0.800	0.1990	0.0686	0.0	0.0
78	0.27	0.10	0.38	39.	33.	36.0	1.72	0.275	0.778	1.053	0.2553	0.0879	0.0	0.0
79	0.0	0.0	0.0	37.	29.	33.0	1.63	0.0	0.094	0.094	0.1576	0.0543	0.0	0.0
80	0.0	0.0	0.0	33.	26.	29.5	1.63	0.0	0.0	0.0	0.0692	0.0238	0.0	0.0
81	0.0	0.23	0.23	33.	29.	31.0	1.86	0.0	0.0	0.0	0.0198	0.0068	0.0	0.0
82	0.0	0.02	0.02	37.	29.	33.0	1.76	0.0	0.115	0.115	0.0299	0.0103	0.0	0.0
83	0.10	0.0	0.10	42.	31.	36.5	1.17	0.100	0.591	0.691	0.2810	0.0968	0.0	0.0
84	0.0	0.0	0.0	37.	30.	33.5	1.03	0.0	0.138	0.138	0.2505	0.0863	0.0	0.0
85	0.0	0.0	0.0	42.	33.	37.5	0.66	0.0	0.373	0.373	0.2316	0.0798	0.0	0.0
86	0.0	0.0	0.0	34.	25.	29.5	0.66	0.0	0.0	0.0	0.1866	0.0643	0.0	0.0
87	0.0	0.0	0.0	32.	11.	21.5	0.66	0.0	0.0	0.0	0.0814	0.0280	0.0	0.0
88	0.0	0.0	0.0	24.	6.	15.0	0.66	0.0	0.0	0.0	0.0348	0.0120	0.0	0.0
89	0.0	0.18	0.18	21.	10.	15.5	0.84	0.0	0.0	0.0	0.0245	0.0084	0.0	0.0
90	0.0	0.05	0.05	24.	16.	20.0	0.89	0.0	0.0	0.0	0.0191	0.0066	0.0	0.0
91	0.0	0.0	0.0	27.	17.	22.0	0.89	0.0	0.0	0.0	0.0145	0.0050	0.0	0.0
92	0.0	0.0	0.0	34.	25.	29.5	0.89	0.0	0.0	0.0	0.0106	0.0036	0.0	0.0
93	0.0	0.0	0.0	37.	22.	29.5	0.83	0.0	0.061	0.061	0.0175	0.0060	0.0	0.0
94	0.0	0.0	0.0	33.	8.	20.5	0.83	0.0	0.0	0.0	0.0116	0.0040	0.0	0.0
95	0.0	0.0	0.0	19.	9.	14.0	0.83	0.0	0.0	0.0	0.0066	0.0023	0.0	0.0
96	0.0	0.15	0.15	22.	14.	18.0	0.98	0.0	0.0	0.0	0.0039	0.0013	0.0	0.0
97	0.0	0.08	0.08	30.	21.	25.5	1.06	0.0	0.0	0.0	0.0015	0.0005	0.0	0.0
98	0.0	0.0	0.0	40.	28.	34.0	0.83	0.0	0.231	0.231	0.0617	0.0213	0.0	0.0
99	0.05	0.05	0.10	36.	26.	31.0	0.73	0.050	0.146	0.196	0.1362	0.0469	0.0	0.0
100	0.0	0.10	0.10	36.	23.	29.5	0.79	0.0	0.046	0.046	0.0853	0.0294	0.0	0.0
101	0.0	0.0	0.0	36.	26.	31.0	0.74	0.0	0.046	0.046	0.0429	0.0148	0.0	0.0
102	0.0	0.0	0.0	29.	23.	26.0	0.74	0.0	0.0	0.0	0.0210	0.0073	0.0	0.0
103	0.0	0.0	0.0	37.	26.	31.5	0.67	0.0	0.072	0.072	0.0250	0.0086	0.0	0.0
104	0.0	0.0	0.0	29.	16.	22.5	0.67	0.0	0.0	0.0	0.0188	0.0065	0.0050	0.0017
105	0.0	0.40	0.40	25.	10.	17.5	1.07	0.0	0.0	0.0	0.0125	0.0043	0.0050	0.0017
106	0.0	0.0	0.0	28.	12.	20.0	1.07	0.0	0.0	0.0	0.0089	0.0031	0.0050	0.0017
107	0.0	0.0	0.0	36.	27.	31.5	1.01	0.0	0.060	0.060	0.0165	0.0057	0.0050	0.0017
108	0.0	0.0	0.0	37.	30.	33.5	0.91	0.0	0.099	0.099	0.0330	0.0114	0.0050	0.0017
109	0.0	0.0	0.0	36.	27.	31.5	0.86	0.0	0.051	0.051	0.0314	0.0108	0.0050	0.0017
110	0.19	0.12	0.31	36.	26.	31.0	0.49	0.190	0.490	0.680	0.3577	0.1232	0.0070	0.0024

Table 6 continued

DAILY SUMMARIES OF SNOW FOR YEAR 1972

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
111	0.43	0.07	0.50	39.	35.	37.0	0.07	0.430	0.491	0.921	0.6762	0.2330	0.1660	0.0572
112	0.72	0.28	1.01	41.	30.	35.5	0.0	0.725	0.355	1.080	0.5441	0.1874	1.4700	0.5064
113	0.23	0.0	0.23	39.	35.	37.0	0.0	0.230	0.0	0.230	0.6443	0.2220	1.1200	0.3858
114	0.0	0.15	0.15	38.	30.	34.0	0.02	0.0	0.133	0.133	0.3355	0.1156	0.3020	0.1040
115	0.0	0.10	0.10	34.	23.	28.5	0.12	0.0	0.0	0.0	0.1865	0.0643	0.1750	0.0603
116	0.0	0.0	0.0	29.	22.	25.5	0.12	0.0	0.0	0.0	0.0820	0.0282	0.0990	0.0341
117	0.0	0.0	0.0	30.	13.	21.5	0.12	0.0	0.0	0.0	0.0350	0.0121	0.0660	0.0227
118	0.0	0.15	0.15	13.	4.	8.5	0.27	0.0	0.0	0.0	0.0246	0.0085	0.0360	0.0124
119	0.0	0.12	0.12	16.	-6.	5.0	0.39	0.0	0.0	0.0	0.0191	0.0066	0.0240	0.0083
120	0.0	0.0	0.0	15.	-6.	4.5	0.39	0.0	0.0	0.0	0.0145	0.0050	0.0160	0.0055
121	0.0	0.0	0.0	22.	1.	11.5	0.39	0.0	0.0	0.0	0.0106	0.0036	0.0130	0.0045
122	0.0	0.0	0.0	26.	13.	19.5	0.39	0.0	0.0	0.0	0.0072	0.0025	0.0120	0.0041
123	0.0	0.0	0.0	22.	5.	13.5	0.39	0.0	0.0	0.0	0.0044	0.0015	0.0070	0.0024
124	0.0	0.0	0.0	14.	-9.	2.5	0.39	0.0	0.0	0.0	0.0020	0.0007	0.0050	0.0017
125	0.0	0.0	0.0	17.	-1.	8.0	0.39	0.0	0.0	0.0	0.0002	0.0001	0.0040	0.0014
126	0.0	0.0	0.0	25.	12.	18.5	0.39	0.0	0.0	0.0	0.0	0.0	0.0030	0.0010
127	0.0	0.11	0.11	29.	19.	24.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0020	0.0007
128	0.0	0.18	0.18	32.	21.	26.5	0.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0
129	0.0	0.17	0.17	34.	30.	32.0	0.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130	0.0	0.0	0.0	41.	33.	37.0	0.50	0.0	0.346	0.346	0.0855	0.0295	0.0	0.0
131	0.0	0.0	0.0	38.	29.	33.5	0.37	0.0	0.132	0.132	0.1366	0.0471	0.0	0.0
132	0.0	0.0	0.0	38.	24.	31.0	0.24	0.0	0.130	0.130	0.1032	0.0356	0.0	0.0
133	0.0	0.0	0.0	38.	27.	32.5	0.09	0.0	0.153	0.153	0.0980	0.0337	0.0	0.0
134	0.0	0.0	0.0	35.	30.	32.5	0.04	0.0	0.048	0.048	0.0715	0.0246	0.0	0.0
135	0.10	0.0	0.10	39.	34.	36.5	0.0	0.100	0.039	0.139	0.0891	0.0307	0.0130	0.0045
136	0.12	0.09	0.21	37.	28.	32.5	0.09	0.120	0.0	0.120	0.0719	0.0248	0.2830	0.0975
137	0.0	0.17	0.17	33.	25.	29.0	0.26	0.0	0.0	0.0	0.0427	0.0147	0.1290	0.0444
138	0.20	0.02	0.22	40.	32.	36.0	0.02	0.200	0.260	0.460	0.2487	0.0857	0.3730	0.1285
139	0.10	0.12	0.23	44.	29.	36.5	0.0	0.105	0.145	0.250	0.2085	0.0718	1.1530	0.3972
140	0.34	0.06	0.40	35.	30.	32.5	0.0	0.340	0.060	0.400	0.1844	0.0635	0.1370	0.0472
141	0.05	0.0	0.05	49.	35.	42.0	0.0	0.050	0.0	0.050	0.2397	0.0826	0.5670	0.1953
142	0.0	0.0	0.0	50.	39.	44.5	0.0	0.0	0.0	0.0	0.1093	0.0376	0.1960	0.0675
143	0.0	0.0	0.0	40.	29.	34.5	0.0	0.0	0.0	0.0	0.0453	0.0156	0.1170	0.0403
144	0.0	0.0	0.0	42.	30.	36.0	0.0	0.0	0.0	0.0	0.0266	0.0092	0.0770	0.0265
145	0.0	0.0	0.0	42.	30.	36.0	0.0	0.0	0.0	0.0	0.0208	0.0072	0.1090	0.0376
146	0.0	0.0	0.0	38.	30.	34.0	0.0	0.0	0.0	0.0	0.0160	0.0055	0.0780	0.0269
147	0.0	0.0	0.0	39.	30.	34.5	0.0	0.0	0.0	0.0	0.0118	0.0041	0.0690	0.0238
148	0.0	0.0	0.0	40.	31.	35.5	0.0	0.0	0.0	0.0	0.0083	0.0029	0.0360	0.0124
149	0.16	0.0	0.16	35.	30.	32.5	0.0	0.160	0.0	0.160	0.0090	0.0031	0.0250	0.0086
150	0.66	0.06	0.72	51.	34.	42.5	0.0	0.660	0.060	0.720	0.3213	0.1107	0.6090	0.2098
151	0.0	0.0	0.0	55.	41.	48.0	0.0	0.0	0.0	0.0	0.1856	0.0639	0.2250	0.0775
152	0.0	0.0	0.0	42.	29.	35.5	0.0	0.0	0.0	0.0	0.0627	0.0216	0.1050	0.0362
153	0.0	0.31	0.31	33.	27.	30.0	0.31	0.0	0.0	0.0	0.0225	0.0078	0.0260	0.0090
154	0.35	0.45	0.80	39.	31.	35.0	0.0	0.350	0.760	1.110	0.4053	0.1396	0.1210	0.0417
155	0.0	0.0	0.0	35.	21.	28.0	0.0	0.0	0.0	0.0	0.3502	0.1206	0.1160	0.0400
156	0.16	0.0	0.16	41.	24.	32.5	0.0	0.160	0.0	0.160	0.1232	0.0425	0.0690	0.0238
157	0.20	0.21	0.41	46.	33.	39.5	0.03	0.200	0.180	0.380	0.2579	0.0889	0.4500	0.1550
158	0.0	0.09	0.09	45.	26.	35.5	0.0	0.0	0.120	0.120	0.1668	0.0575	1.2720	0.4382
159	0.0	0.0	0.0	40.	26.	33.0	0.0	0.0	0.0	0.0	0.0917	0.0316	0.0880	0.0303
160	0.0	0.0	0.0	51.	35.	43.0	0.0	0.0	0.0	0.0	0.0384	0.0132	0.0500	0.0172
161	0.0	0.0	0.0	64.	45.	54.5	0.0	0.0	0.0	0.0	0.0254	0.0087	0.0280	0.0096
162	0.0	0.0	0.0	55.	40.	47.5	0.0	0.0	0.0	0.0	0.0197	0.0068	0.0240	0.0083
163	0.18	0.0	0.18	52.	37.	44.5	0.0	0.180	0.0	0.180	0.0256	0.0088	0.0450	0.0155
164	0.38	0.0	0.38	46.	41.	43.5	0.0	0.380	0.0	0.380	0.1209	0.0416	0.1090	0.0376
165	0.96	0.0	0.96	57.	40.	48.5	0.0	0.960	0.0	0.960	0.4877	0.1680	0.5720	0.1971

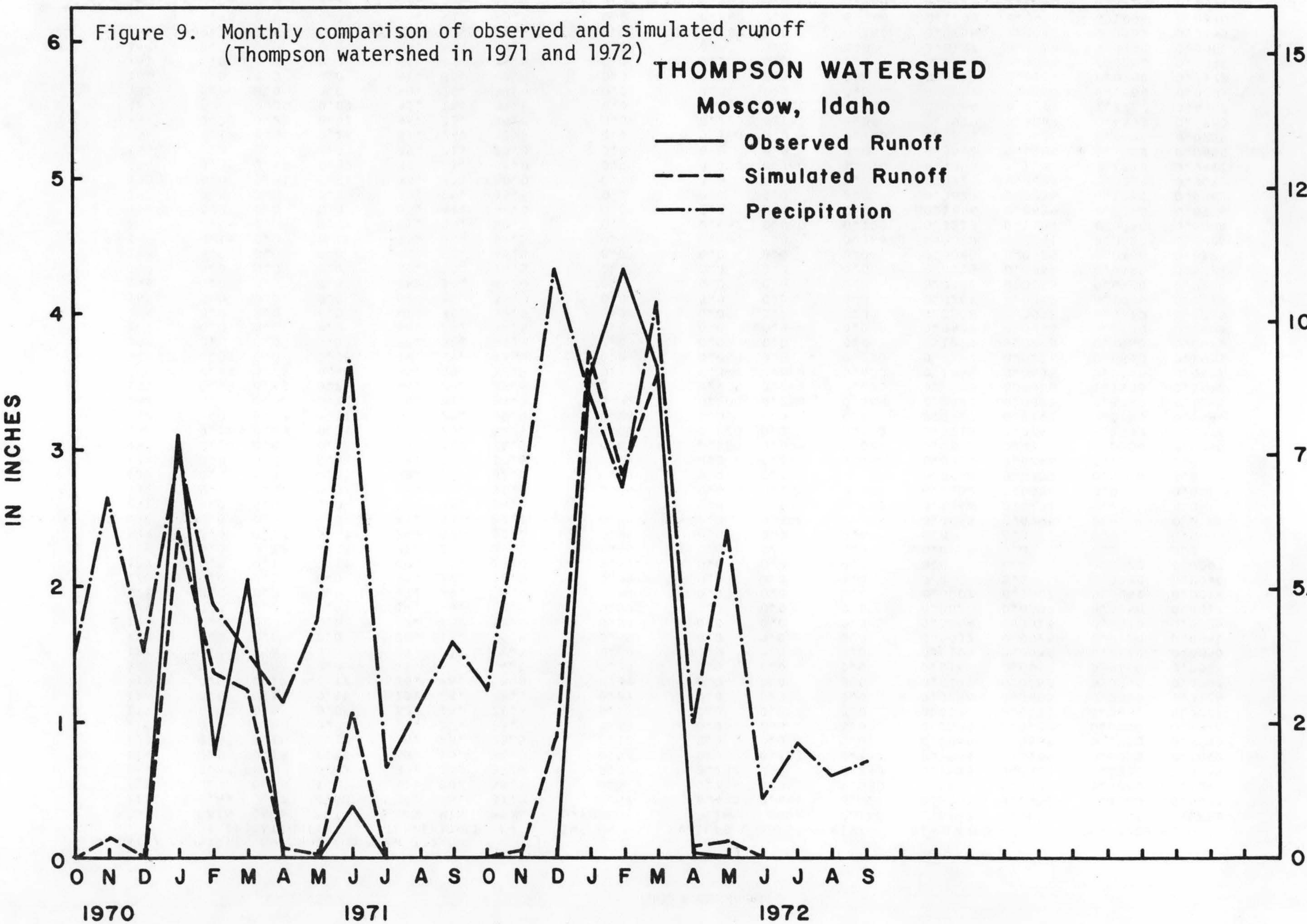

Figure 9. Monthly comparison of observed and simulated runoff (Thompson watershed in 1971 and 1972)

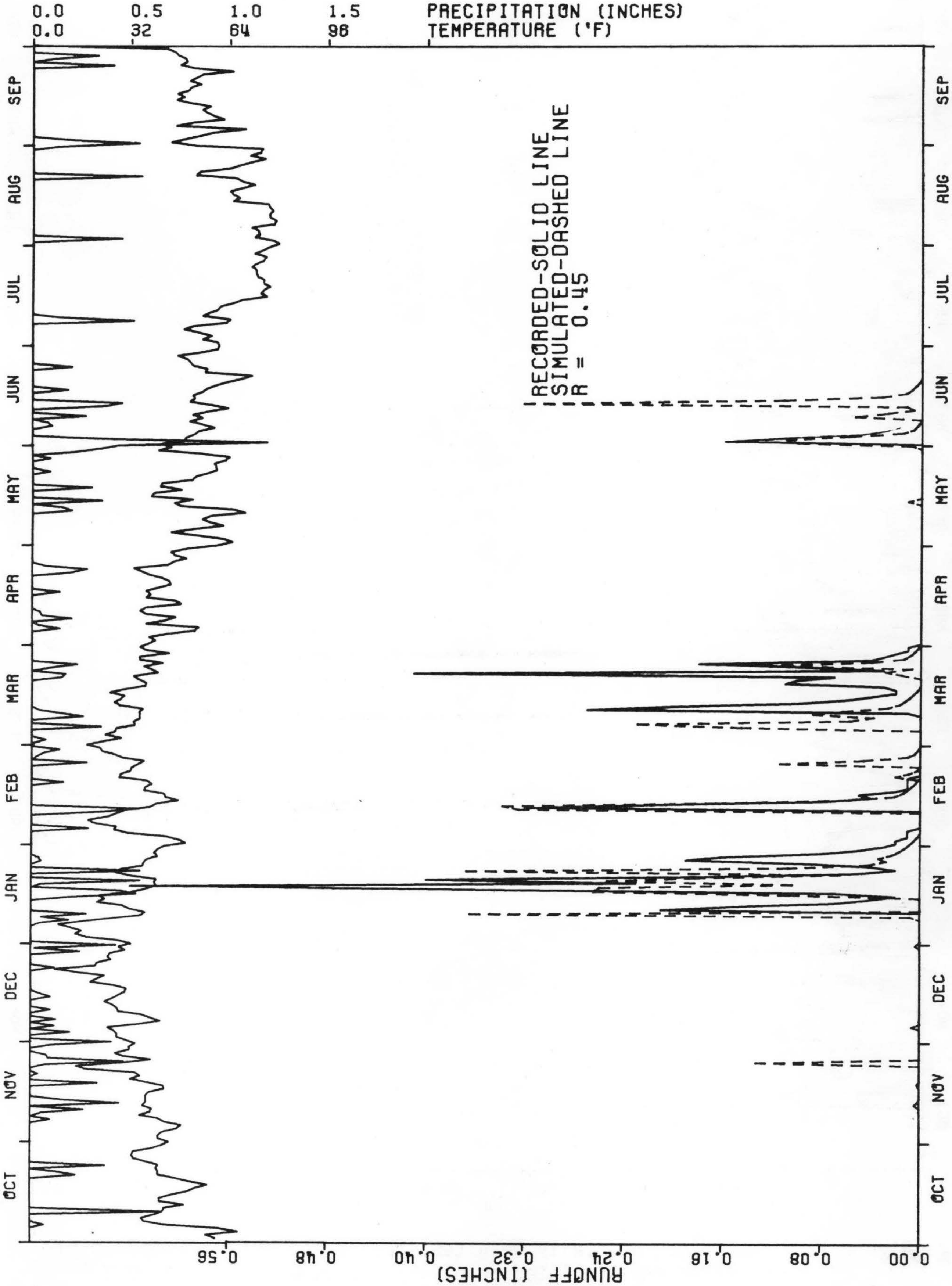

Figure 10. Precipitation, daily mean temperature and daily comparison of observed and simulated runoff (Thompson watershed in 1971)

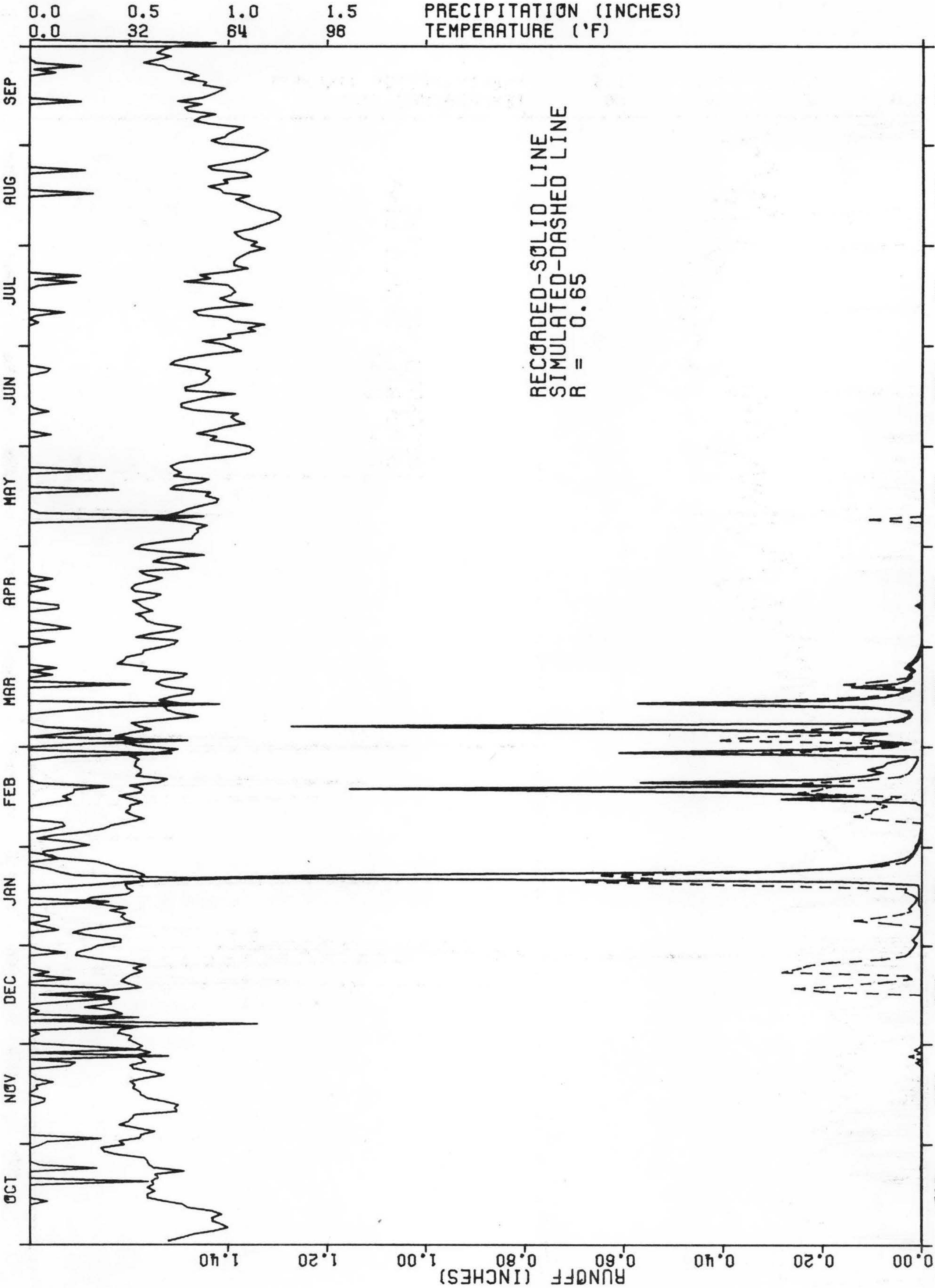

Figure 11. Precipitation, daily mean temperature and daily comparison of observed and simulated runoff (Thompson watershed in 1972)

This watershed had a variety of crops. The main crops cultivated were winter wheat, peas and grass.

Figure 7 shows the routing coefficients derivation. The data used for this simulation were obtained from data collected by the SCS (1941). The observations include very detailed timebreak hydrographs, especially during high runoff periods. These data were very useful in estimating routing coefficients of the upper two soil layers. Four flow regimes for subsurface flow were finally used.

Studies by Bloomsburg (1959) and Davis and Molnau (19 73) have shown that groundwater recharge is a function of precipitation.

Because of the variable annual precipitation for the three years of study, the groundwater recharge rate was varied. The recharge rates were finally set to 0.0005 inches per hour for 1938 and 1939 and 0.002 inches per hour for 1940.

The A horizon soil parameters were adopted from the Thompson watershed. For the B horizon, these values were calculated from moisture tension data published by Holtan and others (1968). The remainder of the required parameters were obtained using the same methods outlined for the Thompson watershed.

Appendix 5 shows the parameters actually used. The monthly summary is shown in Table 7 and Figure 12. Tables 8, 9 and 10 show daily water movement during the runoff seasons. The graphical comparisons of the daily simulated and observed runoffs are shown in Figures 13, 14 and 15.

Some observations about the simulation are:

1. The high simulated runoff at the end of December of 1938 was basically caused by the snowmelt equation since this equation adds two times of the amount of precipitation. This tives much too high a value for the moisture input. The high rainfall matches with the peak.

2. The low simulation of the end of March (day 171) 1939 could be explained by noting that the snow was melted too fast. The overall simulation for 1939 was poor. The two high simulated peaks (days 135 and 163) are the most significant examples of the low initial soil moisture conditions and the poor snowmelt simulation. The initial soil moisture was adopted from the summary table of 1938 in Appendix 4.

3. The winter of water year 1940 was of moderate precipitation. Therefore, only a small snowmelt effect is expected. The simulation matches the observed except for early February. This does not seem to be caused by snowmelt, but by the high rainfall and high initial soil moisture.

Table 7. Monthly summary of water movement - Pitzen Farm Watershed

Year	Month	Precip.	Rain and Snowmelt	ET	GW Recharge	Observed Runoff	Simulated Runoff
1937	Oct	1.32	1.320	0.363	0.0	0.0	0.0
	Nov	3.55	3.550	0.418	0.0	0.0	0.010
	Dec	4.20	4.199	0.163	0.057	0.162	1.245
1938	Jan	1.74	1.700	0.144	0.372	1.210	1.144
	Feb	1.75	1.791	0.298	0.336	1.639	1.239
	Mar	1.94	1.940	0.728	0.372	1.674	0.886
	Apr	1.52	1.520	2.176	0.286	0.449	0.343
	May	1.47	1.470	1.583	0.009	0.011	0.005
	June	1.14	1.140	3.161	0.0	0.0	0.0
	Aug	0.18	0.180	0.603	0.0	0.0	0.0
	Sep	0.75	0.750	0.287	0.0	0.0	0.0
Total		19.67	19.670	13.162	1.432	5.145	4.873
	Oct	1.64	1.640	0.505	0.0	0.0	0.009
	Nov	2.37	2.369	0.372	0.0	0.0	0.018
	Dec	1.24	1.241	0.134	0.0	0.007	0.0
1939	Jan	1.51	1.510	0.185	0.001	0.010	0.002
	Feb	3.54	2.435	0.219	0.205	0.553	2.019
	Mar	2.46	2.565	0.694	0.392	4.510	1.853
	Apr	0.39	0.390	1.898	0.088	0.163	0.023
	May	0.92	0.920	1.508	0.003	0.0	0.000
	June	0.79	0.790	2.297	0.0	0.0	0.0
	July	0.79	0.770	2.832	0.0	0.0	0.0
	Aug	0.0	0.0	0.847	0.0	0.0	0.0
	Sep	0.39	0.390	0.184	0.0	0.0	0.0
Total		16.0	16.000	11.665	0.699	5.243	3.923
	Oct	1.19	1.190	0.240	0.0	0.0	0.0
	Nov	0.28	0.280	0.254	0.0	0.0	0.0
	Dec	4.25	4.250	0.136	0.0	0.008	0.050
1940	Jan	1.73	1.723	0.132	0.018	0.065	0.038
	Feb	4.71	4.717	0.350	1.252	0.782	2.615
	Mar	3.07	3.070	0.800	0.994	1.511	1.265
	Apr	2.18	2.180	1.268	0.635	0.337	0.406
	May	0.84	0.840	2.315	0.354	0.024	0.187
	June	0.50	0.500	3.265	0.0	0.0	0.0
	July	1.73	1.730	2.169	0.0	0.0	0.0
	Aug	0.0	0.0	1.531	0.0	0.0	0.0
	Sep	4.10	4.100	1.408	0.0	0.0	0.084
Total		24.58	24.580	13.868	3.254	3.727	4.644

Note: All values are in inches

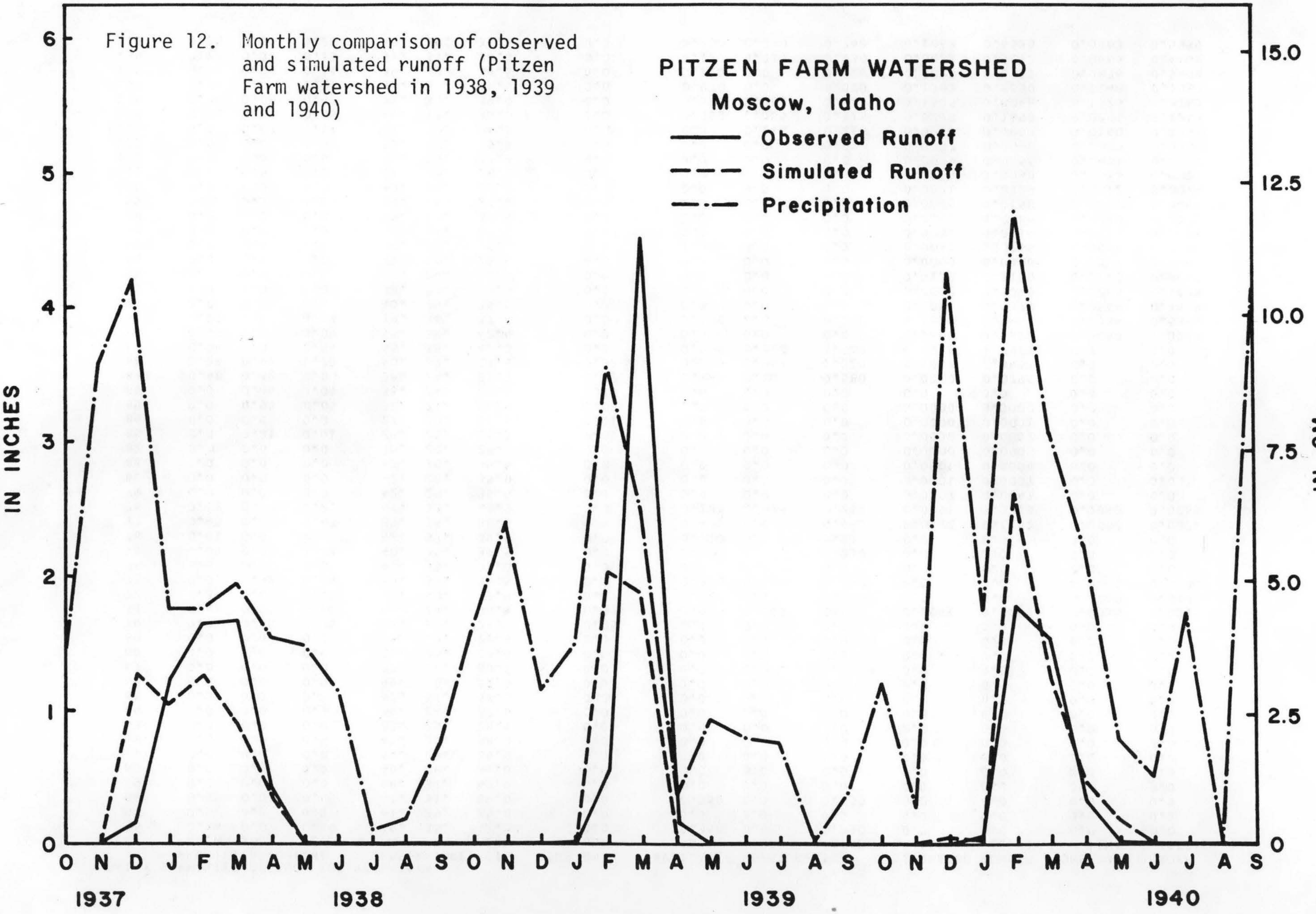

Figure 12. Monthly comparison of observed and simulated runoff (Pitzen Farm watershed in 1938, 1939 and 1940)

Table 8. Daily summary of some rainy and snowmelt seasons (Pitzen Farm watershed in 1938)

DAILY SUMMARIES OF SNOW FOR YEAR 1938

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
56	0.34	0.0	0.34	49.	35.	42.0	0.0	0.340	0.0	0.340	0.0	0.0	0.0	0.0
57	0.0	0.0	0.0	41.	29.	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	0.55	0.0	0.55	47.	31.	39.0	0.0	0.550	0.0	0.550	0.0	0.0	0.0	0.0
59	0.0	0.0	0.0	48.	37.	42.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	40.	28.	34.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61	0.0	0.0	0.0	41.	29.	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	0.0	0.0	0.0	45.	31.	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	32.	25.	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	0.0	0.0	0.0	36.	28.	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	42.	32.	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	0.0	0.0	0.0	44.	30.	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67	0.0	0.0	0.0	33.	28.	30.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	0.0	0.0	0.0	30.	25.	27.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
69	0.0	0.0	0.0	25.	18.	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.05	0.05	33.	23.	28.0	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71	0.46	0.15	0.62	44.	29.	36.5	0.0	0.465	0.205	0.670	0.0041	0.0251	0.0035	0.0216
72	0.38	0.0	0.38	45.	40.	42.5	0.0	0.380	0.0	0.380	0.0	0.0	0.0029	0.0179
73	0.02	0.02	0.04	40.	33.	36.5	0.0	0.020	0.020	0.040	0.0	0.0	0.0001	0.0006
74	0.0	0.0	0.0	43.	33.	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	0.03	0.0	0.03	40.	35.	37.5	0.0	0.030	0.0	0.030	0.0	0.0	0.0	0.0
76	0.01	0.0	0.01	42.	37.	39.5	0.0	0.010	0.0	0.010	0.0	0.0	0.0	0.0
77	0.43	0.0	0.43	39.	34.	36.5	0.0	0.430	0.0	0.430	0.0192	0.1182	0.0052	0.0321
78	0.18	0.02	0.21	47.	33.	40.0	0.0	0.185	0.025	0.210	0.0051	0.0313	0.0043	0.0265
79	0.0	0.0	0.0	42.	29.	35.5	0.0	0.0	0.0	0.0	0.0007	0.0043	0.0	0.0
80	0.0	0.0	0.0	42.	28.	35.0	0.0	0.0	0.0	0.0	0.0001	0.0007	0.0	0.0
81	0.0	0.0	0.0	43.	30.	36.5	0.0	0.0	0.0	0.0	0.0001	0.0004	0.0	0.0
82	0.0	0.0	0.0	30.	27.	28.5	0.0	0.0	0.0	0.0	0.0000	0.0003	0.0	0.0
83	0.0	0.01	0.01	28.	25.	26.5	0.01	0.0	0.0	0.0	0.0000	0.0002	0.0	0.0
84	0.0	0.0	0.0	27.	20.	23.5	0.01	0.0	0.0	0.0	0.0000	0.0001	0.0	0.0
85	0.0	0.05	0.05	32.	21.	26.5	0.06	0.0	0.0	0.0	0.0000	0.0000	0.0	0.0
86	0.0	0.04	0.04	33.	24.	28.5	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87	0.48	0.32	0.80	38.	24.	31.0	0.32	0.480	0.100	0.580	0.0129	0.0795	0.0	0.0
88	0.28	0.95	1.23	40.	27.	33.5	0.32	0.280	0.949	1.229	0.4857	2.9953	0.0	0.0
89	0.04	0.0	0.04	46.	38.	42.0	0.0	0.040	0.320	0.360	0.2916	1.7987	0.0	0.0
90	0.09	0.0	0.09	45.	39.	42.0	0.0	0.090	0.0	0.090	0.1604	0.9896	0.0060	0.0370
91	0.17	0.0	0.17	39.	36.	37.5	0.0	0.170	0.0	0.170	0.1619	0.9986	0.0834	0.5144
92	0.0	0.0	0.0	40.	29.	34.5	0.0	0.0	0.0	0.0	0.1034	0.6377	0.0569	0.3509
93	0.0	0.0	0.0	38.	28.	33.0	0.0	0.0	0.0	0.0	0.0502	0.3098	0.0264	0.1628
94	0.0	0.0	0.0	40.	24.	32.0	0.0	0.0	0.0	0.0	0.0178	0.1100	0.0160	0.0987
95	0.0	0.0	0.0	35.	22.	28.5	0.0	0.0	0.0	0.0	0.0050	0.0306	0.0078	0.0481
96	0.0	0.0	0.0	28.	22.	25.0	0.0	0.0	0.0	0.0	0.0040	0.0248	0.0046	0.0284
97	0.0	0.0	0.0	29.	24.	26.5	0.0	0.0	0.0	0.0	0.0035	0.0219	0.0028	0.0173
98	0.0	0.0	0.0	28.	23.	25.5	0.0	0.0	0.0	0.0	0.0031	0.0189	0.0020	0.0123
99	0.0	0.0	0.0	29.	25.	27.0	0.0	0.0	0.0	0.0	0.0026	0.0158	0.0016	0.0099
100	0.0	0.0	0.0	30.	26.	28.0	0.0	0.0	0.0	0.0	0.0021	0.0127	0.0012	0.0074
101	0.0	0.0	0.0	31.	25.	28.0	0.0	0.0	0.0	0.0	0.0014	0.0088	0.0013	0.0080
102	0.0	0.0	0.0	44.	30.	37.0	0.0	0.0	0.0	0.0	0.0009	0.0056	0.0481	0.2967
103	0.0	0.0	0.0	32.	27.	29.5	0.0	0.0	0.0	0.0	0.0007	0.0042	0.0055	0.0339
104	0.0	0.17	0.17	38.	30.	34.0	0.05	0.0	0.116	0.116	0.0015	0.0093	0.0140	0.0863
105	0.06	0.0	0.06	40.	32.	36.0	0.0	0.060	0.055	0.115	0.0275	0.1698	0.0201	0.1240
106	0.34	0.08	0.42	45.	33.	39.0	0.0	0.340	0.080	0.420	0.1305	0.8046	0.1323	0.8160
107	0.07	0.0	0.07	45.	38.	41.5	0.0	0.070	0.0	0.070	0.1383	0.8530	0.1148	0.7080
108	0.11	0.0	0.11	39.	30.	34.5	0.0	0.110	0.0	0.110	0.1023	0.6311	0.0876	0.5403
109	0.12	0.01	0.13	41.	31.	36.0	0.0	0.120	0.010	0.130	0.0822	0.5072	0.0665	0.4101
110	0.20	0.04	0.24	40.	29.	34.5	0.0	0.200	0.040	0.240	0.1068	0.6588	0.0963	0.5939

Table 8 continued

DAILY SUMMARIES OF SNOW FOR YEAR 1938

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
111	0.0	0.0	0.0	39.	28.	33.5	0.0	0.0	0.0	0.0	0.1097	0.6769	0.0686	0.4231
112	0.02	0.0	0.02	38.	25.	31.5	0.0	0.020	0.0	0.020	0.0542	0.3345	0.0569	0.3509
113	0.09	0.09	0.19	45.	33.	39.0	0.0	0.095	0.095	0.190	0.0692	0.4268	0.0981	0.6050
114	0.16	0.0	0.16	42.	38.	40.0	0.0	0.160	0.0	0.160	0.1029	0.6348	0.1304	0.8042
115	0.0	0.0	0.0	38.	27.	32.5	0.0	0.0	0.0	0.0	0.0613	0.3780	0.0634	0.3910
116	0.0	0.0	0.0	39.	24.	31.5	0.0	0.0	0.0	0.0	0.0241	0.1487	0.0365	0.2251
117	0.0	0.0	0.0	39.	27.	33.0	0.0	0.0	0.0	0.0	0.0106	0.0652	0.0207	0.1277
118	0.0	0.0	0.0	41.	28.	34.5	0.0	0.0	0.0	0.0	0.0087	0.0536	0.0186	0.1147
119	0.0	0.0	0.0	44.	31.	37.5	0.0	0.0	0.0	0.0	0.0080	0.0492	0.0253	0.1560
120	0.02	0.11	0.13	45.	33.	39.0	0.11	0.020	0.0	0.020	0.0076	0.0467	0.0230	0.1419
121	0.0	0.03	0.03	33.	13.	23.0	0.14	0.0	0.0	0.0	0.0069	0.0428	0.0125	0.0771
122	0.0	0.01	0.01	23.	3.	13.0	0.15	0.0	0.0	0.0	0.0000	0.0000	0.0013	0.0080
123	0.0	0.0	0.0	38.	18.	28.0	0.04	0.0	0.109	0.109	0.0006	0.0037	0.0060	0.0370
124	0.13	0.02	0.15	40.	22.	31.0	0.0	0.130	0.061	0.191	0.0396	0.2442	0.0458	0.2825
125	0.07	0.0	0.07	41.	34.	37.5	0.0	0.070	0.0	0.070	0.0679	0.4187	0.0575	0.3546
126	0.0	0.08	0.08	41.	30.	35.5	0.0	0.0	0.080	0.080	0.0723	0.4462	0.0494	0.3047
127	0.0	0.02	0.02	39.	30.	34.5	0.01	0.0	0.010	0.010	0.0350	0.2158	0.0315	0.1943
128	0.0	0.0	0.0	38.	26.	32.0	0.0	0.0	0.010	0.010	0.0145	0.0897	0.0257	0.1585
129	0.0	0.62	0.62	34.	30.	32.0	0.62	0.0	0.0	0.0	0.0090	0.0554	0.0225	0.1388
130	0.0	0.13	0.13	37.	29.	33.0	0.65	0.0	0.099	0.099	0.0164	0.1011	0.0425	0.2621
131	0.02	0.04	0.06	38.	27.	32.5	0.52	0.020	0.166	0.186	0.0391	0.2412	0.0330	0.2035
132	0.0	0.0	0.0	37.	21.	29.0	0.40	0.0	0.128	0.128	0.0722	0.4451	0.0343	0.2115
133	0.0	0.0	0.0	46.	33.	39.5	0.0	0.0	0.397	0.397	0.1454	0.8968	0.0669	0.4126
134	0.05	0.09	0.14	41.	33.	37.0	0.09	0.050	0.0	0.050	0.1352	0.8341	0.1099	0.6778
135	0.0	0.34	0.34	35.	28.	31.5	0.41	0.0	0.018	0.018	0.0922	0.5687	0.0517	0.3189
136	0.0	0.0	0.0	37.	25.	31.0	0.31	0.0	0.098	0.098	0.0568	0.3501	0.0982	0.6056
137	0.0	0.0	0.0	42.	29.	35.5	0.0	0.0	0.314	0.314	0.0957	0.5903	0.0873	0.5384
138	0.0	0.0	0.0	33.	28.	30.5	0.0	0.0	0.0	0.0	0.1107	0.6830	0.0704	0.4342
139	0.0	0.0	0.0	32.	17.	24.5	0.0	0.0	0.0	0.0	0.0551	0.3398	0.0419	0.2584
140	0.0	0.0	0.0	34.	16.	25.0	0.0	0.0	0.0	0.0	0.0140	0.0862	0.0348	0.2146
141	0.0	0.03	0.03	33.	23.	28.0	0.03	0.0	0.0	0.0	0.0186	0.1146	0.0295	0.1819
142	0.0	0.09	0.09	35.	27.	31.0	0.10	0.0	0.017	0.017	0.0157	0.0970	0.0311	0.1918
143	0.0	0.0	0.0	37.	21.	29.0	0.0	0.0	0.103	0.103	0.0215	0.1328	0.0308	0.1900
144	0.0	0.02	0.02	35.	33.	34.0	0.0	0.0	0.020	0.020	0.0249	0.1537	0.0531	0.3275
145	0.0	0.0	0.0	43.	33.	38.0	0.0	0.0	0.0	0.0	0.0162	0.1002	0.0866	0.5341
146	0.0	0.0	0.0	39.	32.	35.5	0.0	0.0	0.0	0.0	0.0142	0.0875	0.0876	0.5403
147	0.0	0.0	0.0	41.	32.	36.5	0.0	0.0	0.0	0.0	0.0133	0.0819	0.0879	0.5421
148	0.0	0.0	0.0	48.	29.	38.5	0.0	0.0	0.0	0.0	0.0121	0.0744	0.0884	0.5452
149	0.0	0.0	0.0	43.	27.	35.0	0.0	0.0	0.0	0.0	0.0113	0.0695	0.0803	0.4952
150	0.0	0.0	0.0	45.	31.	38.0	0.0	0.0	0.0	0.0	0.0103	0.0638	0.0790	0.4872
151	0.0	0.0	0.0	52.	29.	40.5	0.0	0.0	0.0	0.0	0.0096	0.0590	0.0810	0.4996
152	0.07	0.0	0.07	45.	40.	42.5	0.0	0.070	0.0	0.070	0.0100	0.0615	0.0927	0.5717
153	0.18	0.0	0.18	47.	34.	40.5	0.0	0.180	0.0	0.180	0.0127	0.0784	0.0944	0.5822
154	0.0	0.0	0.0	48.	35.	41.5	0.0	0.0	0.0	0.0	0.0255	0.1572	0.0673	0.4151
155	0.0	0.0	0.0	46.	34.	40.0	0.0	0.0	0.0	0.0	0.0097	0.0600	0.0454	0.2800
156	0.10	0.12	0.22	41.	33.	37.0	0.0	0.100	0.120	0.220	0.0359	0.2215	0.0798	0.4922
157	0.0	0.0	0.0	46.	34.	40.0	0.0	0.0	0.0	0.0	0.0145	0.0892	0.0432	0.2664
158	0.0	0.0	0.0	51.	32.	41.5	0.0	0.0	0.0	0.0	0.0300	0.1848	0.0336	0.2072
159	0.0	0.0	0.0	54.	34.	44.0	0.0	0.0	0.0	0.0	0.0197	0.1216	0.0271	0.1671
160	0.01	0.0	0.01	49.	32.	40.5	0.0	0.010	0.0	0.010	0.0130	0.0800	0.0274	0.1690
161	0.0	0.0	0.0	52.	32.	42.0	0.0	0.0	0.0	0.0	0.0080	0.0494	0.0221	0.1363
162	0.0	0.0	0.0	55.	39.	47.0	0.0	0.0	0.0	0.0	0.0064	0.0397	0.0199	0.1227
163	0.09	0.0	0.09	57.	49.	53.0	0.0	0.090	0.0	0.090	0.0085	0.0523	0.0270	0.1665
164	0.02	0.0	0.02	49.	40.	44.5	0.0	0.020	0.0	0.020	0.0058	0.0357	0.0200	0.1233
165	0.23	0.0	0.23	43.	35.	39.0	0.0	0.230	0.0	0.230	0.0066	0.0407	0.0229	0.1412

Table 8 continued

DAILY SUMMARIES OF SNOW FOR YEAR 1938

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
166	0.15	0.0	0.15	43.	32.	37.5	0.0	0.150	0.0	0.150	0.0401	0.2474	0.0447	0.2757
167	0.02	0.12	0.14	38.	32.	35.0	0.0	0.020	0.120	0.140	0.0780	0.4809	0.0576	0.3552
168	0.0	0.06	0.06	34.	27.	30.5	0.06	0.0	0.0	0.0	0.0689	0.4252	0.0354	0.2183
169	0.31	0.12	0.43	40.	29.	34.5	0.0	0.310	0.180	0.490	0.1479	0.9124	0.0708	0.4367
170	0.0	0.0	0.0	40.	32.	36.0	0.0	0.0	0.0	0.0	0.1057	0.6517	0.1464	0.9029
171	0.0	0.0	0.0	38.	26.	32.0	0.0	0.0	0.0	0.0	0.0422	0.2603	0.0954	0.5884
172	0.0	0.0	0.0	38.	23.	30.5	0.0	0.0	0.0	0.0	0.0338	0.2082	0.0629	0.3879
173	0.15	0.0	0.15	39.	25.	32.0	0.0	0.150	0.0	0.150	0.0250	0.1540	0.0493	0.3041
174	0.07	0.0	0.07	49.	31.	40.0	0.0	0.070	0.0	0.070	0.0289	0.1780	0.1416	0.8733
175	0.06	0.0	0.06	40.	35.	37.5	0.0	0.060	0.0	0.060	0.0354	0.2181	0.0825	0.5088
176	0.0	0.0	0.0	48.	34.	41.0	0.0	0.0	0.0	0.0	0.0166	0.1021	0.0605	0.3731
177	0.0	0.0	0.0	51.	33.	42.0	0.0	0.0	0.0	0.0	0.0112	0.0693	0.0509	0.3139
178	0.01	0.0	0.01	55.	36.	45.5	0.0	0.010	0.0	0.010	0.0104	0.0638	0.0421	0.2596
179	0.0	0.05	0.05	37.	29.	33.0	0.0	0.0	0.050	0.050	0.0112	0.0689	0.0378	0.2331
180	0.0	0.0	0.0	38.	24.	31.0	0.0	0.0	0.0	0.0	0.0092	0.0569	0.0289	0.1782
181	0.0	0.0	0.0	40.	26.	33.0	0.0	0.0	0.0	0.0	0.0082	0.0509	0.0238	0.1468
182	0.0	0.0	0.0	43.	30.	36.5	0.0	0.0	0.0	0.0	0.0074	0.0454	0.0206	0.1270
183	0.0	0.0	0.0	50.	29.	39.5	0.0	0.0	0.0	0.0	0.0059	0.0363	0.0175	0.1079
184	0.0	0.0	0.0	55.	32.	43.5	0.0	0.0	0.0	0.0	0.0051	0.0312	0.0143	0.0882
185	0.15	0.0	0.15	50.	34.	42.0	0.0	0.150	0.0	0.150	0.0078	0.0483	0.0233	0.1437
186	0.55	0.0	0.55	42.	34.	38.0	0.0	0.550	0.0	0.550	0.0851	0.5251	0.0958	0.5908
187	0.01	0.0	0.01	45.	35.	40.0	0.0	0.010	0.0	0.010	0.1032	0.6365	0.0318	0.1961
188	0.0	0.0	0.0	50.	33.	41.5	0.0	0.0	0.0	0.0	0.0465	0.2870	0.0202	0.1246
189	0.0	0.0	0.0	57.	34.	45.5	0.0	0.0	0.0	0.0	0.0164	0.1014	0.0153	0.0944
190	0.0	0.0	0.0	58.	39.	48.5	0.0	0.0	0.0	0.0	0.0073	0.0448	0.0135	0.0833
191	0.01	0.0	0.01	48.	38.	43.0	0.0	0.010	0.0	0.010	0.0065	0.0400	0.0143	0.0882
192	0.0	0.0	0.0	54.	33.	43.5	0.0	0.0	0.0	0.0	0.0056	0.0343	0.0108	0.0666
193	0.0	0.0	0.0	56.	37.	46.5	0.0	0.0	0.0	0.0	0.0049	0.0303	0.0083	0.0512
194	0.08	0.0	0.08	45.	40.	42.5	0.0	0.080	0.0	0.080	0.0066	0.0407	0.0137	0.0845
195	0.0	0.0	0.0	52.	32.	42.0	0.0	0.0	0.0	0.0	0.0030	0.0186	0.0093	0.0574
196	0.0	0.0	0.0	53.	36.	44.5	0.0	0.0	0.0	0.0	0.0032	0.0198	0.0073	0.0450
197	0.02	0.0	0.02	55.	36.	45.5	0.0	0.020	0.0	0.020	0.0043	0.0268	0.0063	0.0389
198	0.29	0.0	0.29	55.	44.	49.5	0.0	0.290	0.0	0.290	0.0061	0.0375	0.0255	0.1573
199	0.32	0.0	0.32	57.	49.	53.0	0.0	0.320	0.0	0.320	0.0097	0.0599	0.0501	0.3090
200	0.09	0.0	0.09	50.	44.	47.0	0.0	0.090	0.0	0.090	0.0054	0.0331	0.0314	0.1937
201	0.0	0.0	0.0	51.	32.	41.5	0.0	0.0	0.0	0.0	0.0026	0.0163	0.0101	0.0623
202	0.0	0.0	0.0	56.	33.	44.5	0.0	0.0	0.0	0.0	0.0016	0.0101	0.0065	0.0401
203	0.0	0.0	0.0	60.	38.	49.0	0.0	0.0	0.0	0.0	0.0010	0.0060	0.0049	0.0302
204	0.0	0.0	0.0	58.	41.	49.5	0.0	0.0	0.0	0.0	0.0008	0.0047	0.0043	0.0265
205	0.0	0.0	0.0	61.	37.	49.0	0.0	0.0	0.0	0.0	0.0006	0.0040	0.0034	0.0210
206	0.0	0.0	0.0	62.	43.	52.5	0.0	0.0	0.0	0.0	0.0007	0.0042	0.0026	0.0160
207	0.0	0.0	0.0	57.	42.	49.5	0.0	0.0	0.0	0.0	0.0006	0.0040	0.0025	0.0154
208	0.0	0.0	0.0	55.	40.	47.5	0.0	0.0	0.0	0.0	0.0006	0.0037	0.0018	0.0111
209	0.0	0.0	0.0	64.	39.	51.5	0.0	0.0	0.0	0.0	0.0006	0.0035	0.0016	0.0099
210	0.0	0.0	0.0	75.	45.	60.0	0.0	0.0	0.0	0.0	0.0005	0.0033	0.0013	0.0080
211	0.0	0.0	0.0	74.	45.	59.5	0.0	0.0	0.0	0.0	0.0005	0.0031	0.0010	0.0062
212	0.0	0.0	0.0	73.	44.	58.5	0.0	0.0	0.0	0.0	0.0005	0.0030	0.0006	0.0037
213	0.0	0.0	0.0	55.	45.	50.0	0.0	0.0	0.0	0.0	0.0005	0.0028	0.0006	0.0037
214	0.0	0.0	0.0	51.	32.	41.5	0.0	0.0	0.0	0.0	0.0004	0.0026	0.0003	0.0019
215	0.02	0.0	0.02	47.	32.	39.5	0.0	0.020	0.0	0.020	0.0004	0.0025	0.0005	0.0031
216	0.02	0.0	0.02	49.	34.	41.5	0.0	0.020	0.0	0.020	0.0004	0.0023	0.0006	0.0037
217	0.0	0.0	0.0	52.	32.	42.0	0.0	0.0	0.0	0.0	0.0003	0.0021	0.0006	0.0037
218	0.01	0.0	0.01	58.	32.	45.0	0.0	0.010	0.0	0.010	0.0003	0.0020	0.0006	0.0037
219	0.04	0.0	0.04	60.	35.	47.5	0.0	0.040	0.0	0.040	0.0003	0.0018	0.0006	0.0037
220	0.03	0.0	0.03	60.	40.	50.0	0.0	0.030	0.0	0.030	0.0003	0.0017	0.0006	0.0037

Table 9. Daily summary of some rainy and snowmelt seasons (Pitzen Farm watershed in 1939)

DAILY SUMMARIES OF SNOW FOR YEAR 1939

DAY	PRECIPITATION(IN)			TEMPERATURE(F)			SWE ON	AVAILABLE MOISTURE(IN)			SIMULATED RUNOFF		OBSERVED RUNOFF	
	RAIN	SNOW	TOT	MAX	MIN	MEAN	GROUND	RAIN	SNOW	TOTAL	(IN)	(CFS)	(IN)	(CFS)
111	0.0	0.0	0.0	45.	36.	40.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0017	0.0105
112	0.0	0.0	0.0	41.	30.	35.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0017	0.0105
113	0.0	0.0	0.0	38.	25.	31.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0005	0.0031
114	0.0	0.0	0.0	38.	25.	31.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115	0.0	0.0	0.0	42.	28.	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116	0.07	0.0	0.07	41.	30.	35.5	0.0	0.070	0.0	0.070	0.0	0.0	0.0002	0.0012
117	0.0	0.0	0.0	38.	25.	31.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0004	0.0025
118	0.0	0.0	0.0	38.	29.	33.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
119	0.09	0.01	0.10	40.	33.	36.5	0.01	0.090	0.0	0.090	0.0	0.0	0.0002	0.0012
120	0.04	0.04	0.08	39.	30.	34.5	0.0	0.040	0.050	0.090	0.0015	0.0096	0.0003	0.0019
121	0.01	0.03	0.04	42.	30.	36.0	0.0	0.010	0.030	0.040	0.0006	0.0040	0.0003	0.0019
122	0.0	0.0	0.0	38.	26.	32.0	0.0	0.0	0.0	0.0	0.0000	0.0003	0.0002	0.0012
123	0.0	0.0	0.0	31.	25.	28.0	0.0	0.0	0.0	0.0	0.0000	0.0001	0.0	0.0
124	0.0	0.02	0.02	31.	23.	27.0	0.02	0.0	0.0	0.0	0.0000	0.0001	0.0005	0.0031
125	0.0	0.0	0.0	27.	20.	23.5	0.02	0.0	0.0	0.0	0.0000	0.0000	0.0	0.0
126	0.0	0.0	0.0	34.	21.	27.5	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
127	0.0	0.40	0.40	33.	26.	29.5	0.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0
128	0.01	0.09	0.10	37.	20.	28.5	0.40	0.010	0.111	0.121	0.0016	0.0101	0.0	0.0
129	0.0	0.25	0.25	31.	28.	29.5	0.65	0.0	0.0	0.0	0.0002	0.0012	0.0	0.0
130	0.02	0.08	0.10	35.	25.	30.0	0.68	0.020	0.054	0.074	0.0015	0.0090	0.0	0.0
131	0.0	0.05	0.05	25.	5.	15.0	0.73	0.0	0.0	0.0	0.0001	0.0003	0.0	0.0
132	0.0	0.0	0.0	16.	-6.	5.0	0.73	0.0	0.0	0.0	0.0000	0.0000	0.0	0.0
133	0.0	0.0	0.0	18.	10.	14.0	0.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0
134	0.18	0.27	0.45	35.	6.	20.5	0.56	0.180	0.437	0.617	0.0	0.0	0.0	0.0
135	0.52	0.0	0.52	40.	36.	38.0	0.0	0.520	0.558	1.078	0.6026	3.7163	0.0151	0.0931
136	0.0	0.0	0.0	37.	31.	34.0	0.0	0.0	0.0	0.0	0.0976	0.6019	0.0172	0.1061
137	0.64	0.60	1.24	37.	32.	34.5	0.24	0.640	0.360	1.000	0.2673	1.6484	0.0122	0.0752
138	0.0	0.19	0.19	36.	31.	33.5	0.38	0.0	0.052	0.052	0.3255	2.0078	0.0817	0.5039
139	0.0	0.0	0.0	39.	19.	29.0	0.20	0.0	0.183	0.183	0.2162	1.3334	0.0793	0.4891
140	0.0	0.0	0.0	41.	29.	35.0	0.0	0.0	0.195	0.195	0.1957	1.2069	0.0541	0.3337
141	0.0	0.0	0.0	44.	34.	39.0	0.0	0.0	0.0	0.0	0.1412	0.8706	0.0473	0.2917
142	0.0	0.0	0.0	37.	24.	30.5	0.0	0.0	0.0	0.0	0.0852	0.5253	0.0424	0.2615
143	0.0	0.0	0.0	37.	23.	30.0	0.0	0.0	0.0	0.0	0.0374	0.2306	0.0318	0.1961
144	0.0	0.0	0.0	38.	20.	29.0	0.0	0.0	0.0	0.0	0.0130	0.0801	0.0254	0.1567
145	0.0	0.0	0.0	40.	24.	32.0	0.0	0.0	0.0	0.0	0.0060	0.0371	0.0227	0.1400
146	0.0	0.0	0.0	41.	21.	31.0	0.0	0.0	0.0	0.0	0.0052	0.0322	0.0187	0.1153
147	0.0	0.0	0.0	43.	30.	36.5	0.0	0.0	0.0	0.0	0.0046	0.0281	0.0204	0.1258
148	0.0	0.07	0.07	34.	29.	31.5	0.07	0.0	0.0	0.0	0.0042	0.0260	0.0221	0.1363
149	0.0	0.0	0.0	38.	29.	33.5	0.0	0.0	0.070	0.070	0.0045	0.0276	0.0225	0.1388
150	0.01	0.14	0.15	35.	25.	30.0	0.10	0.010	0.035	0.045	0.0043	0.0263	0.0209	0.1289
151	0.0	0.0	0.0	34.	24.	29.0	0.10	0.0	0.0	0.0	0.0038	0.0232	0.0183	0.1129
152	0.01	0.0	0.01	36.	23.	29.5	0.04	0.010	0.066	0.076	0.0065	0.0400	0.0174	0.1073
153	0.02	0.0	0.02	40.	23.	31.5	0.0	0.020	0.039	0.059	0.0128	0.0789	0.0191	0.1178
154	0.0	0.13	0.13	33.	29.	31.0	0.13	0.0	0.0	0.0	0.0076	0.0472	0.0225	0.1388
155	0.0	0.06	0.06	29.	23.	26.0	0.19	0.0	0.0	0.0	0.0039	0.0243	0.0183	0.1129
156	0.0	0.0	0.0	37.	19.	28.0	0.10	0.0	0.089	0.089	0.0070	0.0432	0.0160	0.0987
157	0.09	0.20	0.29	38.	28.	33.0	0.0	0.090	0.301	0.391	0.0804	0.4961	0.0160	0.0987
158	0.0	0.02	0.02	41.	23.	32.0	0.0	0.0	0.020	0.020	0.1085	0.6689	0.0160	0.0987
159	0.02	0.0	0.02	42.	24.	33.0	0.0	0.020	0.0	0.020	0.0520	0.3210	0.0153	0.0944
160	0.0	0.01	0.01	37.	27.	32.0	0.0	0.0	0.010	0.010	0.0165	0.1020	0.0147	0.0907
161	0.01	0.0	0.01	43.	29.	36.0	0.0	0.010	0.0	0.010	0.0058	0.0358	0.0195	0.1203
162	1.04	0.25	1.29	38.	35.	36.5	0.25	1.040	0.0	1.040	0.1801	1.1110	0.0894	0.5514
163	0.20	0.26	0.46	44.	32.	38.0	0.0	0.200	0.510	0.710	0.5026	3.0996	0.1513	0.9331
164	0.08	0.0	0.08	38.	29.	33.5	0.0	0.080	0.0	0.080	0.3481	2.1468	0.1176	0.7253
165	0.0	0.0	0.0	42.	27.	34.5	0.0	0.0	0.0	0.0	0.2059	1.2696	0.0952	0.5871

DAILY SUMMARIES OF SNOW FOR YEAR 1939

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
166	0.01	0.03	0.04	38.	30.	34.0	0.0	0.010	0.030	0.040	0.1256	0.7749	0.0769	0.4743
167	0.0	0.0	0.0	44.	33.	38.5	0.0	0.0	0.0	0.0	0.0704	0.4339	0.1068	0.6587
168	0.02	0.0	0.02	46.	36.	41.0	0.0	0.020	0.0	0.020	0.0302	0.1860	0.2437	1.5030
169	0.0	0.0	0.0	56.	36.	46.0	0.0	0.0	0.0	0.0	0.0133	0.0820	0.3931	2.4244
170	0.0	0.0	0.0	63.	35.	49.0	0.0	0.0	0.0	0.0	0.0098	0.0604	0.4989	3.0769
171	0.0	0.0	0.0	67.	41.	54.0	0.0	0.0	0.0	0.0	0.0090	0.0554	0.5717	3.5259
172	0.0	0.0	0.0	67.	42.	54.5	0.0	0.0	0.0	0.0	0.0083	0.0509	0.5524	3.4069
173	0.0	0.0	0.0	68.	43.	55.5	0.0	0.0	0.0	0.0	0.0075	0.0465	0.4892	3.0171
174	0.0	0.0	0.0	68.	44.	56.0	0.0	0.0	0.0	0.0	0.0069	0.0423	0.3465	2.1370
175	0.0	0.0	0.0	68.	43.	55.5	0.0	0.0	0.0	0.0	0.0062	0.0382	0.2158	1.3309
176	0.0	0.0	0.0	59.	43.	51.0	0.0	0.0	0.0	0.0	0.0056	0.0345	0.1330	0.8203
177	0.0	0.0	0.0	48.	36.	42.0	0.0	0.0	0.0	0.0	0.0050	0.0308	0.0789	0.4866
178	0.0	0.0	0.0	54.	30.	42.0	0.0	0.0	0.0	0.0	0.0045	0.0278	0.0555	0.3423
179	0.0	0.0	0.0	55.	30.	42.5	0.0	0.0	0.0	0.0	0.0043	0.0265	0.0426	0.2627
180	0.0	0.0	0.0	56.	31.	43.5	0.0	0.0	0.0	0.0	0.0030	0.0184	0.0307	0.1893
181	0.0	0.0	0.0	60.	39.	49.5	0.0	0.0	0.0	0.0	0.0029	0.0179	0.0252	0.1554
182	0.0	0.0	0.0	61.	43.	52.0	0.0	0.0	0.0	0.0	0.0033	0.0203	0.0212	0.1307
183	0.0	0.0	0.0	61.	45.	53.0	0.0	0.0	0.0	0.0	0.0027	0.0168	0.0162	0.0999
184	0.0	0.0	0.0	63.	38.	50.5	0.0	0.0	0.0	0.0	0.0017	0.0105	0.0143	0.0882
185	0.0	0.0	0.0	53.	45.	49.0	0.0	0.0	0.0	0.0	0.0010	0.0064	0.0118	0.0728
186	0.0	0.0	0.0	49.	30.	39.5	0.0	0.0	0.0	0.0	0.0011	0.0069	0.0083	0.0512
187	0.0	0.0	0.0	50.	30.	40.0	0.0	0.0	0.0	0.0	0.0008	0.0046	0.0065	0.0401
188	0.0	0.0	0.0	55.	29.	42.0	0.0	0.0	0.0	0.0	0.0007	0.0041	0.0070	0.0432
189	0.0	0.0	0.0	61.	36.	48.5	0.0	0.0	0.0	0.0	0.0007	0.0041	0.0062	0.0382
190	0.0	0.0	0.0	57.	42.	49.5	0.0	0.0	0.0	0.0	0.0006	0.0039	0.0045	0.0278
191	0.02	0.0	0.02	49.	39.	44.0	0.0	0.020	0.0	0.020	0.0006	0.0037	0.0044	0.0271
192	0.0	0.0	0.0	57.	31.	44.0	0.0	0.0	0.0	0.0	0.0006	0.0035	0.0045	0.0278
193	0.0	0.0	0.0	58.	36.	47.0	0.0	0.0	0.0	0.0	0.0005	0.0033	0.0034	0.0210
194	0.07	0.24	0.32	39.	31.	35.0	0.0	0.075	0.245	0.320	0.0064	0.0395	0.0362	0.2233
195	0.0	0.0	0.0	48.	33.	40.5	0.0	0.0	0.0	0.0	0.0005	0.0031	0.0166	0.1024
196	0.0	0.0	0.0	56.	30.	43.0	0.0	0.0	0.0	0.0	0.0005	0.0029	0.0072	0.0444
197	0.0	0.0	0.0	55.	36.	45.5	0.0	0.0	0.0	0.0	0.0004	0.0027	0.0037	0.0228
198	0.0	0.0	0.0	61.	31.	46.0	0.0	0.0	0.0	0.0	0.0004	0.0025	0.0020	0.0123
199	0.0	0.0	0.0	70.	39.	54.5	0.0	0.0	0.0	0.0	0.0004	0.0024	0.0014	0.0086
200	0.0	0.0	0.0	73.	45.	59.0	0.0	0.0	0.0	0.0	0.0004	0.0022	0.0013	0.0080
201	0.0	0.0	0.0	62.	36.	49.0	0.0	0.0	0.0	0.0	0.0003	0.0021	0.0013	0.0080
202	0.0	0.0	0.0	73.	40.	56.5	0.0	0.0	0.0	0.0	0.0003	0.0019	0.0013	0.0080
203	0.0	0.0	0.0	75.	47.	61.0	0.0	0.0	0.0	0.0	0.0003	0.0018	0.0006	0.0037
204	0.0	0.0	0.0	63.	47.	55.0	0.0	0.0	0.0	0.0	0.0003	0.0016	0.0006	0.0037
205	0.0	0.0	0.0	64.	38.	51.0	0.0	0.0	0.0	0.0	0.0002	0.0015	0.0006	0.0037
206	0.0	0.0	0.0	50.	38.	44.0	0.0	0.0	0.0	0.0	0.0002	0.0014	0.0006	0.0037
207	0.03	0.0	0.03	54.	39.	46.5	0.0	0.030	0.0	0.030	0.0002	0.0013	0.0017	0.0105
208	0.0	0.0	0.0	70.	37.	53.5	0.0	0.0	0.0	0.0	0.0002	0.0011	0.0007	0.0043
209	0.0	0.0	0.0	80.	45.	62.5	0.0	0.0	0.0	0.0	0.0002	0.0010	0.0003	0.0019
210	0.0	0.0	0.0	88.	55.	71.5	0.0	0.0	0.0	0.0	0.0001	0.0009	0.0	0.0
211	0.0	0.0	0.0	55.	48.	51.5	0.0	0.0	0.0	0.0	0.0001	0.0008	0.0	0.0
212	0.0	0.0	0.0	68.	40.	54.0	0.0	0.0	0.0	0.0	0.0001	0.0007	0.0	0.0
213	0.0	0.0	0.0	75.	40.	57.5	0.0	0.0	0.0	0.0	0.0001	0.0006	0.0	0.0
214	0.0	0.0	0.0	75.	55.	65.0	0.0	0.0	0.0	0.0	0.0001	0.0005	0.0	0.0
215	0.0	0.0	0.0	66.	48.	57.0	0.0	0.0	0.0	0.0	0.0001	0.0004	0.0	0.0
216	0.0	0.0	0.0	68.	40.	54.0	0.0	0.0	0.0	0.0	0.0001	0.0003	0.0	0.0
217	0.0	0.0	0.0	59.	32.	45.5	0.0	0.0	0.0	0.0	0.0000	0.0002	0.0	0.0
218	0.0	0.0	0.0	63.	32.	47.5	0.0	0.0	0.0	0.0	0.0000	0.0001	0.0	0.0
219	0.0	0.0	0.0	61.	41.	51.0	0.0	0.0	0.0	0.0	0.0000	0.0001	0.0	0.0
220	0.0	0.0	0.0	73.	42.	57.5	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0	0.0

Table 10. Daily summary of some rainy and snowmelt seasons (Pitzen Farm watershed in 1940)

DAILY SUMMARIES OF SNOW FOR YEAR 1940

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
111	0.0	0.0	0.0	24.	11.	17.5	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0	0.0
112	0.0	0.0	0.0	29.	17.	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
113	0.0	0.0	0.0	24.	14.	19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114	0.0	0.0	0.0	35.	21.	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115	0.0	0.0	0.0	31.	23.	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116	0.0	0.0	0.0	23.	13.	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
117	0.0	0.07	0.07	25.	15.	20.0	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
118	0.09	0.22	0.31	35.	20.	27.5	0.05	0.090	0.242	0.332	0.0048	0.0295	0.0	0.0
119	0.16	0.0	0.16	40.	35.	37.5	0.0	0.160	0.046	0.206	0.0128	0.0787	0.0030	0.0185
120	0.0	0.0	0.0	48.	37.	42.5	0.0	0.0	0.0	0.0	0.0005	0.0033	0.0176	0.1085
121	0.0	0.0	0.0	49.	36.	42.5	0.0	0.0	0.0	0.0	0.0000	0.0001	0.0139	0.0857
122	0.0	0.0	0.0	47.	34.	40.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0072	0.0444
123	0.0	0.0	0.0	49.	33.	41.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0020	0.0123
124	0.0	0.0	0.0	44.	22.	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
125	0.0	0.05	0.05	32.	26.	29.0	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126	0.09	0.07	0.16	42.	29.	35.5	0.0	0.090	0.126	0.216	0.0020	0.0121	0.0095	0.0586
127	0.04	0.10	0.14	48.	31.	39.5	0.0	0.040	0.100	0.140	0.0381	0.2351	0.0162	0.0999
128	0.32	0.06	0.38	40.	31.	35.5	0.0	0.320	0.060	0.380	0.0386	0.2383	0.0266	0.1641
129	1.17	0.0	1.17	45.	37.	41.0	0.0	1.170	0.0	1.170	0.5201	3.2079	0.2682	1.6541
130	0.0	0.0	0.0	43.	35.	39.0	0.0	0.0	0.0	0.0	0.3128	1.9291	0.0460	0.2837
131	0.15	0.0	0.15	43.	30.	36.5	0.0	0.150	0.0	0.150	0.1762	1.0865	0.0424	0.2615
132	0.25	0.0	0.25	44.	37.	40.5	0.0	0.250	0.0	0.250	0.1756	1.0831	0.0735	0.4533
133	0.05	0.0	0.05	41.	37.	39.0	0.0	0.050	0.0	0.050	0.1290	0.7956	0.0413	0.2547
134	0.0	0.0	0.0	42.	30.	36.0	0.0	0.0	0.0	0.0	0.0564	0.3480	0.0140	0.0863
135	0.0	0.0	0.0	42.	29.	35.5	0.0	0.0	0.0	0.0	0.0154	0.0948	0.0186	0.1147
136	0.13	0.05	0.18	35.	31.	33.0	0.02	0.130	0.031	0.161	0.0350	0.2159	0.0172	0.1061
137	0.0	0.01	0.01	39.	32.	35.5	0.0	0.0	0.030	0.030	0.0258	0.1588	0.0356	0.2196
138	0.0	0.0	0.0	38.	29.	33.5	0.0	0.0	0.0	0.0	0.0055	0.0339	0.0195	0.1203
139	0.06	0.0	0.06	38.	28.	33.0	0.0	0.060	0.0	0.060	0.0051	0.0312	0.0165	0.1018
140	0.26	0.06	0.32	39.	33.	36.0	0.01	0.265	0.045	0.310	0.0437	0.2698	0.0583	0.3596
141	0.09	0.09	0.18	38.	31.	34.5	0.0	0.090	0.100	0.190	0.1123	0.6927	0.1036	0.6389
142	0.0	0.0	0.0	43.	31.	37.0	0.0	0.0	0.0	0.0	0.0570	0.3517	0.0467	0.2880
143	0.0	0.0	0.0	44.	28.	36.0	0.0	0.0	0.0	0.0	0.0154	0.0948	0.0307	0.1893
144	0.0	0.0	0.0	43.	28.	35.5	0.0	0.0	0.0	0.0	0.0175	0.1079	0.0233	0.1437
145	0.0	0.09	0.09	34.	27.	30.5	0.09	0.0	0.0	0.0	0.0053	0.0329	0.0191	0.1178
146	0.0	0.03	0.03	42.	28.	35.0	0.0	0.0	0.120	0.120	0.0121	0.0746	0.0286	0.1764
147	0.14	0.0	0.14	44.	32.	38.0	0.0	0.140	0.0	0.140	0.0066	0.0404	0.0468	0.2886
148	0.48	0.0	0.48	48.	37.	42.5	0.0	0.480	0.0	0.480	0.1316	0.8114	0.1692	1.0435
149	0.25	0.0	0.25	47.	38.	42.5	0.0	0.250	0.0	0.250	0.1669	1.0295	0.1543	0.9516
150	0.24	0.0	0.24	46.	37.	41.5	0.0	0.240	0.0	0.240	0.1833	1.1305	0.1609	0.9923
151	0.36	0.0	0.36	51.	40.	45.5	0.0	0.360	0.0	0.360	0.1866	1.1509	0.1995	1.2304
152	0.02	0.0	0.02	49.	39.	44.0	0.0	0.020	0.0	0.020	0.1414	0.8723	0.0954	0.5884
153	0.23	0.0	0.23	49.	34.	41.5	0.0	0.230	0.0	0.230	0.0646	0.3984	0.1085	0.6692
154	0.39	0.0	0.39	46.	38.	42.0	0.0	0.390	0.0	0.390	0.2174	1.3411	0.2272	1.4012
155	0.0	0.0	0.0	51.	31.	41.0	0.0	0.0	0.0	0.0	0.0950	0.5858	0.0722	0.4453
156	0.05	0.0	0.05	45.	36.	40.5	0.0	0.050	0.0	0.050	0.0610	0.3760	0.0605	0.3731
157	0.04	0.0	0.04	44.	32.	38.0	0.0	0.040	0.0	0.040	0.0278	0.1712	0.0562	0.3466
158	0.0	0.0	0.0	46.	32.	39.0	0.0	0.0	0.0	0.0	0.0048	0.0295	0.0354	0.2183
159	0.84	0.0	0.84	45.	36.	40.5	0.0	0.840	0.0	0.840	0.1425	0.8787	0.2752	1.6973
160	0.01	0.0	0.01	43.	33.	38.0	0.0	0.010	0.0	0.010	0.2258	1.3924	0.0828	0.5107
161	0.0	0.0	0.0	48.	29.	38.5	0.0	0.0	0.0	0.0	0.0951	0.5864	0.0607	0.3744
162	0.0	0.0	0.0	43.	27.	35.0	0.0	0.0	0.0	0.0	0.0329	0.2029	0.0438	0.2701
163	0.04	0.0	0.04	39.	26.	32.5	0.0	0.040	0.0	0.040	0.0242	0.1490	0.0420	0.2590
164	0.0	0.0	0.0	41.	29.	35.0	0.0	0.0	0.0	0.0	0.0043	0.0266	0.0332	0.2048
165	0.0	0.0	0.0	49.	30.	39.5	0.0	0.0	0.0	0.0	0.0031	0.0192	0.0255	0.1573

DAILY SUMMARIES OF SNOW FOR YEAR 1940

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
166	0.0	0.0	0.0	58.	35.	46.5	0.0	0.0	0.0	0.0	0.0019	0.0119	0.0206	0.1270
167	0.0	0.0	0.0	62.	41.	51.5	0.0	0.0	0.0	0.0	0.0009	0.0054	0.0162	0.0999
168	0.12	0.0	0.12	45.	44.	44.5	0.0	0.120	0.0	0.120	0.0017	0.0103	0.0346	0.2134
169	0.0	0.0	0.0	53.	31.	42.0	0.0	0.0	0.0	0.0	0.0004	0.0026	0.0134	0.0826
170	0.0	0.0	0.0	55.	32.	43.5	0.0	0.0	0.0	0.0	0.0007	0.0040	0.0107	0.0660
171	0.0	0.0	0.0	59.	33.	46.0	0.0	0.0	0.0	0.0	0.0006	0.0035	0.0087	0.0537
172	0.0	0.0	0.0	61.	36.	48.5	0.0	0.0	0.0	0.0	0.0005	0.0031	0.0069	0.0426
173	0.0	0.0	0.0	64.	36.	50.0	0.0	0.0	0.0	0.0	0.0004	0.0027	0.0061	0.0376
174	0.0	0.0	0.0	63.	38.	50.5	0.0	0.0	0.0	0.0	0.0004	0.0023	0.0044	0.0271
175	0.0	0.0	0.0	64.	38.	51.0	0.0	0.0	0.0	0.0	0.0003	0.0019	0.0039	0.0241
176	0.0	0.0	0.0	59.	46.	52.5	0.0	0.0	0.0	0.0	0.0002	0.0015	0.0042	0.0259
177	0.58	0.0	0.58	58.	43.	50.5	0.0	0.580	0.0	0.580	0.0443	0.2735	0.0741	0.4570
178	0.18	0.0	0.18	54.	42.	48.0	0.0	0.180	0.0	0.180	0.0857	0.5284	0.0592	0.3651
179	0.0	0.0	0.0	52.	40.	46.0	0.0	0.0	0.0	0.0	0.0434	0.2675	0.0143	0.0882
180	0.02	0.0	0.02	54.	38.	46.0	0.0	0.020	0.0	0.020	0.0450	0.2775	0.0071	0.0438
181	0.06	0.0	0.06	52.	41.	46.5	0.0	0.060	0.0	0.060	0.0062	0.0385	0.0117	0.0722
182	0.0	0.0	0.0	53.	42.	47.5	0.0	0.0	0.0	0.0	0.0019	0.0120	0.0073	0.0450
183	0.51	0.0	0.51	50.	41.	45.5	0.0	0.510	0.0	0.510	0.0319	0.1966	0.0843	0.5199
184	0.11	0.0	0.11	50.	40.	45.0	0.0	0.110	0.0	0.110	0.1258	0.7759	0.0513	0.3164
185	0.0	0.0	0.0	51.	34.	42.5	0.0	0.0	0.0	0.0	0.0492	0.3035	0.0117	0.0722
186	0.0	0.0	0.0	55.	32.	43.5	0.0	0.0	0.0	0.0	0.0062	0.0382	0.0074	0.0456
187	0.02	0.0	0.02	59.	37.	48.0	0.0	0.020	0.0	0.020	0.0016	0.0097	0.0051	0.0315
188	0.20	0.0	0.20	50.	41.	45.5	0.0	0.200	0.0	0.200	0.0006	0.0034	0.0403	0.2485
189	0.0	0.0	0.0	59.	37.	48.0	0.0	0.0	0.0	0.0	0.0004	0.0027	0.0058	0.0358
190	0.08	0.0	0.08	50.	42.	46.0	0.0	0.080	0.0	0.080	0.0004	0.0023	0.0087	0.0537
191	0.08	0.0	0.08	56.	44.	50.0	0.0	0.080	0.0	0.080	0.0003	0.0019	0.0277	0.1708
192	0.38	0.0	0.38	48.	40.	44.0	0.0	0.380	0.0	0.380	0.0531	0.3272	0.1150	0.7093
193	0.0	0.0	0.0	55.	35.	45.0	0.0	0.0	0.0	0.0	0.0298	0.1840	0.0094	0.0580
194	0.0	0.0	0.0	59.	35.	47.0	0.0	0.0	0.0	0.0	0.0149	0.0916	0.0039	0.0241
195	0.0	0.0	0.0	70.	44.	57.0	0.0	0.0	0.0	0.0	0.0126	0.0779	0.0016	0.0099
196	0.0	0.0	0.0	68.	48.	58.0	0.0	0.0	0.0	0.0	0.0015	0.0094	0.0015	0.0093
197	0.0	0.0	0.0	57.	41.	49.0	0.0	0.0	0.0	0.0	0.0003	0.0017	0.0010	0.0062
198	0.0	0.0	0.0	54.	40.	47.0	0.0	0.0	0.0	0.0	0.0003	0.0021	0.0007	0.0043
199	0.0	0.0	0.0	57.	32.	44.5	0.0	0.0	0.0	0.0	0.0003	0.0016	0.0003	0.0019
200	0.0	0.0	0.0	65.	43.	54.0	0.0	0.0	0.0	0.0	0.0002	0.0012	0.0003	0.0019
201	0.0	0.0	0.0	61.	46.	53.5	0.0	0.0	0.0	0.0	0.0001	0.0009	0.0003	0.0019
202	0.02	0.0	0.02	62.	41.	51.5	0.0	0.020	0.0	0.020	0.0001	0.0005	0.0	0.0
203	0.0	0.0	0.0	56.	42.	49.0	0.0	0.0	0.0	0.0	0.0000	0.0002	0.0	0.0
204	0.0	0.0	0.0	60.	34.	47.0	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0	0.0
205	0.0	0.0	0.0	66.	40.	53.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
206	0.49	0.0	0.49	46.	40.	43.0	0.0	0.490	0.0	0.490	0.0040	0.0247	0.0059	0.0364
207	0.16	0.0	0.16	57.	39.	48.0	0.0	0.160	0.0	0.160	0.0171	0.1052	0.0087	0.0537
208	0.20	0.0	0.20	55.	40.	47.5	0.0	0.200	0.0	0.200	0.0191	0.1178	0.0127	0.0783
209	0.0	0.0	0.0	57.	43.	50.0	0.0	0.0	0.0	0.0	0.0164	0.1011	0.0028	0.0173
210	0.0	0.0	0.0	55.	41.	48.0	0.0	0.0	0.0	0.0	0.0116	0.0718	0.0005	0.0031
211	0.15	0.0	0.15	52.	41.	46.5	0.0	0.150	0.0	0.150	0.0219	0.1350	0.0031	0.0191
212	0.0	0.0	0.0	52.	35.	43.5	0.0	0.0	0.0	0.0	0.0032	0.0195	0.0002	0.0012
213	0.29	0.0	0.29	49.	33.	41.0	0.0	0.290	0.0	0.290	0.0148	0.0913	0.0112	0.0691
214	0.0	0.0	0.0	72.	42.	57.0	0.0	0.0	0.0	0.0	0.0295	0.1821	0.0016	0.0099
215	0.16	0.0	0.16	73.	52.	62.5	0.0	0.160	0.0	0.160	0.0305	0.1882	0.0015	0.0093
216	0.0	0.0	0.0	59.	38.	48.5	0.0	0.0	0.0	0.0	0.0157	0.0969	0.0006	0.0037
217	0.28	0.0	0.28	56.	46.	51.0	0.0	0.280	0.0	0.280	0.0496	0.3059	0.0198	0.1221
218	0.0	0.0	0.0	53.	38.	45.5	0.0	0.0	0.0	0.0	0.0314	0.1939	0.0006	0.0037
219	0.0	0.0	0.0	59.	37.	48.0	0.0	0.0	0.0	0.0	0.0153	0.0944	0.0001	0.0006
220	0.0	0.0	0.0	64.	42.	53.0	0.0	0.0	0.0	0.0	0.0115	0.0709	0.0	0.0

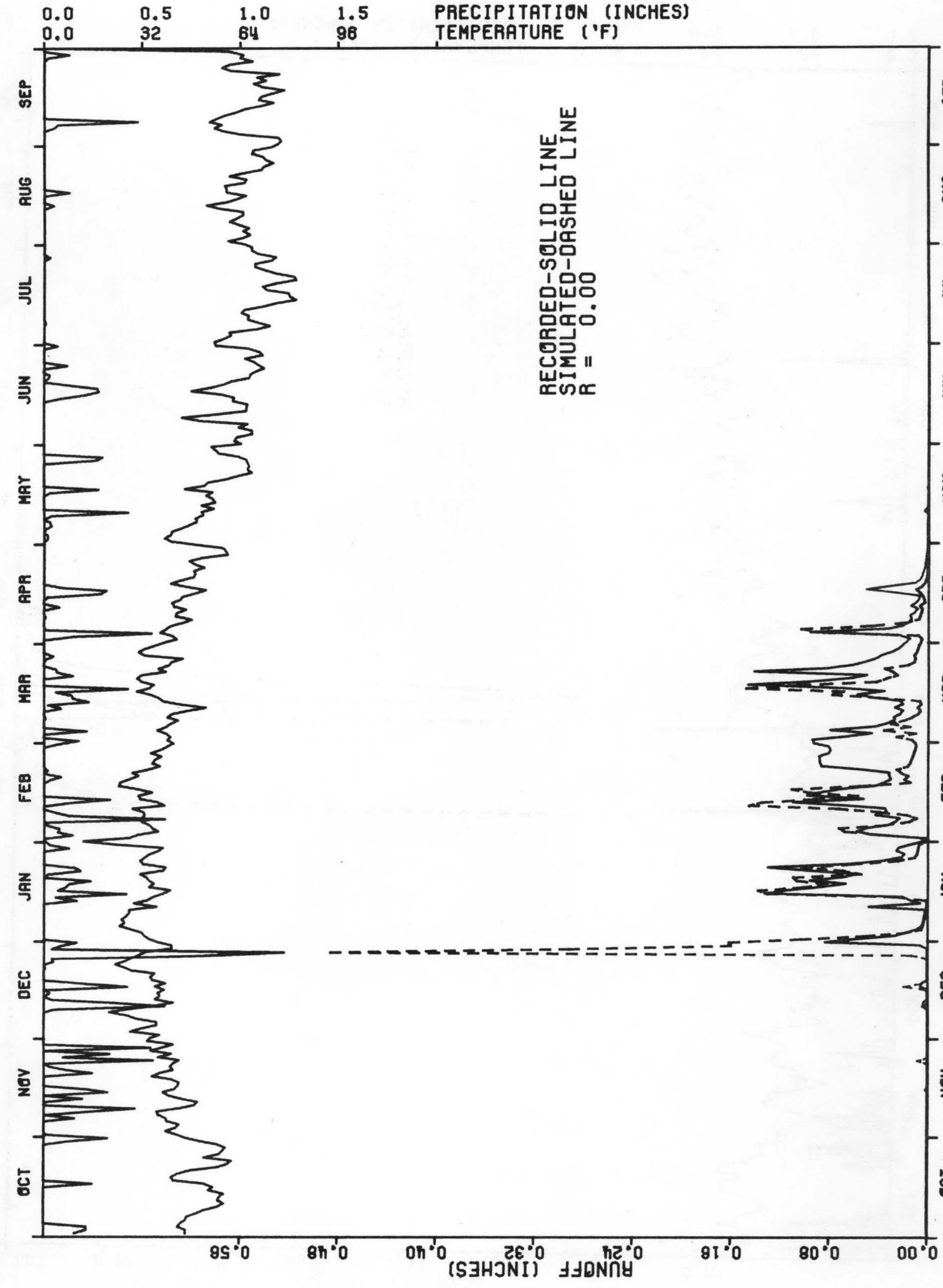

Figure 13. Precipitation, daily mean temperature and daily comparison of observed and simulated runoff (Pitzen Farm watershed in 1938)

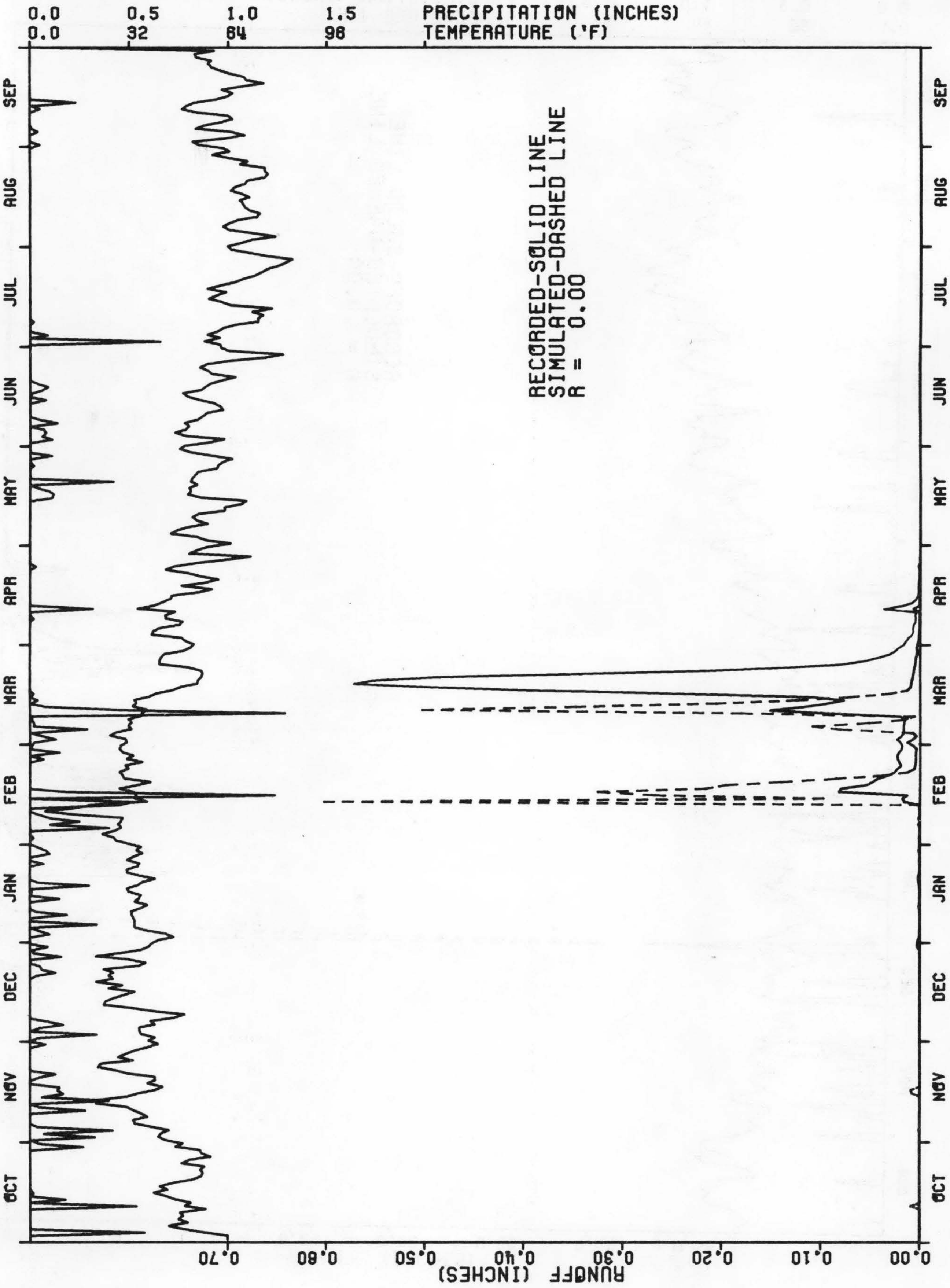

Figure 14. Precipitation, daily mean temperature and daily comparison of observed and simulated runoff (Pitzen Farm watershed in 1939)

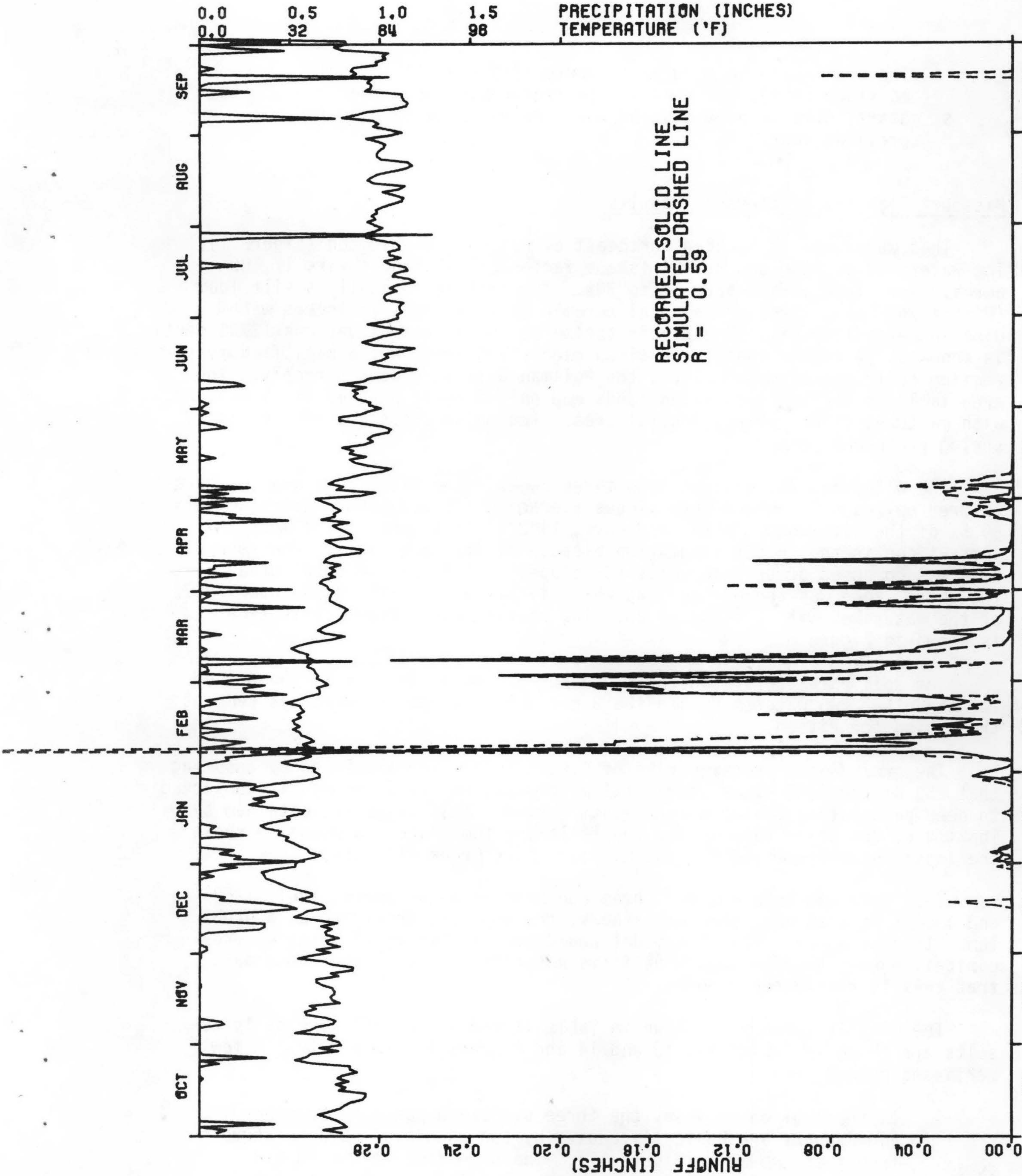

Figure 15. Precipitation, daily mean temperature and daily comparison of observed and simulated runoff (Pitzen Farm watershed in 1940)

The peak could be reduced by decreasing the initial soil moisture (ASM), but this is not reasonable since the s starting value used must be the same as valculated in the previous year.

Missouri Flat Creek Watershed Results

This watershed is located northeast of Pullman, Washington (Figure 1). The watershed is long and narrow (shape factor of .22) and covers 17,600 acres. The slope varies from 5% to 30%. The soil is basically a silt loam (Potter and Love, 1942) and a total aerable soil depth of 72 inches with nine inches of topsoil. The precipitation at the higher elevations (3700 feet) is known to be higher than the Pullman gage (2400 feet) but a satisfactory correction could not be made. Thus, the Pullman data were used directly. The area includes various cultivated lands and only a small part of it is covered with pasture, forest or residential area. The major crops are winter whear, spring grain and peas.

The watershed was divided into three zones. The first zone was the dark-colored upland soils which have slopes averaging 15% and covers approximately 89.5% of the watershed (Potter and Love, 1942). This zone is the most important one in the runoff simulation because of its large size. The second zone was composed of terrace soils (5% slope) on 1.8% of the total area. The third zone was the bottom land which is alluvium. This area covers 8.7% of the watershed with a slope of 2%. The routing coefficient derivation is shown in Figure 8.

The soil parameters used for the A horizon were the same as those used for the other two watersheds and the B horizon's parameters were the same as those used for Pitzen.

The groundwater recharge rate of 0.0025 in/hr was calculated by assuming that 25% of the 1961 water year total precipitation (27.7 inches) is subjected to deep percolation during a four month period. This value was obtained by looking at the water balance for the following two years. Appendix 6 shows the input parameters used for the Missouri Flat Creek watershed.

Test data was obtained for three consecutive water years; 1961, 1962 and 1963. As with the other watersheds, the snowmelt proved to be a problem. It also appears that the model would perform better if weighted precipitation were used as input but it is not totally clear from these data that this is really the problem.

The monthly summary is shown in Table 11 and Figure 16. The daily results are shown in Tables 12, 13 and 14 and Figures 17, 18 and 19. A few pertinent points are:

1. In the 1961 water year, the three simulated peaks in December and January are basically caused by too much available moisture from fast snowmelt (Figure 17). The high simulations in mid February can be explained by poor subsurface or channel rout-

Table 11. Monthly summary of water movement - Missouri Flat Creek watershed

Year	Month	Precip.	Rain and Snowmelt	ET	GW Recharge	Observed Runoff	Simulated Runoff
1960	Oct	2.23	2.230	0.670	0.0	0.025	0.000
	Nov	5.71	5.709	0.404	0.0	0.082	0.013
	Dec	2.24	1.970	0.126	0.225	0.104	0.255
1961	Jan	2.28	2.550	0.128	0.675	0.409	1.013
	Feb	6.10	6.101	0.332	1.666	3.280	4.458
	Mar	2.67	2.670	0.713	1.419	1.870	0.992
	Apr	1.63	1.630	1.569	0.102	0.255	0.028
	May	1.42	1.420	2.053	0.006	0.109	0.001
	June	1.35	1.350	3.786	0.0	0.038	0.0
	July	0.13	0.130	3.470	0.0	0.008	0.0
	Aug	0.68	0.680	1.483	0.0	0.006	0.0
	Sep	1.23	1.230	1.054	0.0	0.006	0.0
Total		27.67	27.669	14.788	4.093	6.10	6.760
	Oct	1.75	1.750	0.594	0.0	0.009	0.001
	Nov	3.48	3.469	0.347	0.0	0.037	0.032
	Dec	3.50	3.498	0.142	0.099	0.158	0.298
1962	Jan	1.53	1.528	0.122	0.799	0.221	0.661
	Feb	1.45	1.169	0.212	0.652	0.205	0.281
	Mar	3.48	3.759	0.631	1.112	1.038	1.956
	Apr	1.67	1.670	2.416	0.280	0.229	0.070
	May	2.11	2.110	1.132	0.140	0.118	0.060
	June	0.56	0.560	2.977	0.0	0.021	0.0
	July	0.38	0.380	3.195	0.0	0.006	0.0
	Aug	0.61	0.610	1.932	0.0	0.006	0.0
	Sep	1.70	1.700	0.006	0.0	0.008	0.004
Total		22.27	22.205	14.737	3.064	2.025	3.363
	Oct	3.32	3.320	0.677	0.0	0.022	0.003
	Nov	2.50	2.500	0.425	0.000	0.030	0.001
	Dec	2.09	2.090	0.171	0.209	0.087	0.140
1963	Jan	1.02	0.460	0.072	0.302	0.047	0.106
	Feb	2.93	3.409	0.325	0.081	1.533	2.074
	Mar	2.09	2.090	0.701	0.209	0.130	0.540
	Apr	1.79	1.789	1.548	0.847	0.057	0.594
	May	0.45	0.450	2.118	0.0	0.016	0.0
	June	2.72	2.720	2.677	0.0	0.016	0.456
	July	0.37	0.370	3.092	0.0	0.017	0.0
	Aug	0.43	0.430	1.959	0.0	0.009	0.0
	Sep	1.03	1.030	1.088	0.0	0.008	0.0
Total		20.72	20.72	14.852	2.644	2.155	3.914

Note: All values are in inches

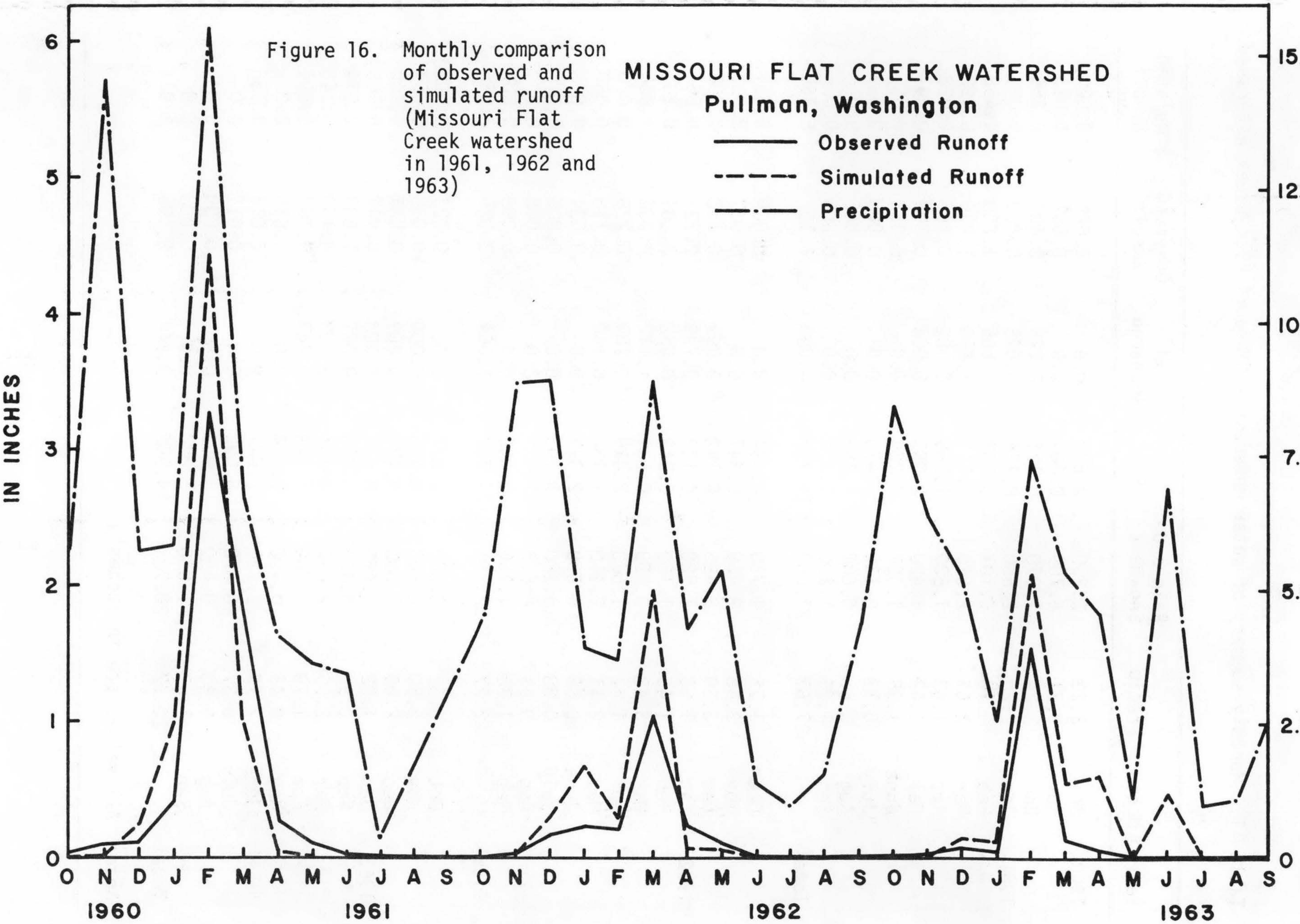

Figure 16. Monthly comparison of observed and simulated runoff (Missouri Flat Creek watershed in 1961, 1962 and 1963)

Table 12. Daily summary of some rainy and snowmelt seasons (Missouri Flat Creek watershed in 1961)

DAILY SUMMARIES OF SNOW FOR YEAR 1961

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
56	0.27	0.21	0.48	39.	31.	35.0	0.0	0.270	0.211	0.481	0.0009	0.6716	0.0270	20.0000
57	0.0	0.0	0.0	33.	25.	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0128	9.5000
58	0.0	0.0	0.0	34.	27.	30.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0054	4.0000
59	0.0	0.0	0.0	30.	23.	26.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0034	2.5000
60	0.0	0.0	0.0	35.	26.	30.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0020	1.5000
61	0.0	0.0	0.0	40.	32.	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0014	1.0000
62	0.0	0.0	0.0	45.	36.	40.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0015	1.1000
63	0.20	0.0	0.20	44.	34.	39.0	0.0	0.200	0.0	0.200	0.0020	1.4669	0.0027	2.0000
64	0.19	0.0	0.19	40.	31.	35.5	0.0	0.190	0.0	0.190	0.0028	2.0779	0.0041	3.0000
65	0.0	0.0	0.0	39.	28.	33.5	0.0	0.0	0.0	0.0	0.0035	2.5969	0.0027	2.0000
66	0.0	0.0	0.0	32.	18.	25.0	0.0	0.0	0.0	0.0	0.0000	0.0144	0.0020	1.5000
67	0.0	0.0	0.0	30.	20.	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0014	1.0000
68	0.0	0.0	0.0	32.	19.	25.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0011	0.8000
69	0.0	0.0	0.0	33.	17.	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0009	0.7000
70	0.0	0.0	0.0	28.	14.	21.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0008	0.6000
71	0.0	0.0	0.0	25.	18.	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0008	0.6000
72	0.0	0.0	0.0	38.	22.	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0008	0.6000
73	0.0	0.0	0.0	45.	35.	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0008	0.6000
74	0.0	0.0	0.0	45.	35.	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0008	0.6000
75	0.0	0.05	0.05	39.	27.	33.0	0.0	0.0	0.050	0.050	0.0002	0.1403	0.0012	0.9000
76	0.0	0.0	0.0	34.	22.	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0011	0.8000
77	0.0	0.0	0.0	32.	22.	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0008	0.6000
78	0.0	0.15	0.15	33.	22.	27.5	0.15	0.0	0.0	0.0	0.0	0.0	0.0008	0.6000
79	0.75	0.12	0.88	39.	27.	33.0	0.0	0.755	0.275	1.030	0.0525	38.8459	0.0065	4.8000
80	0.0	0.0	0.0	40.	35.	37.5	0.0	0.0	0.0	0.0	0.0431	31.8961	0.0338	25.0000
81	0.03	0.0	0.03	36.	30.	33.0	0.0	0.030	0.0	0.030	0.0134	9.8748	0.0074	5.5000
82	0.0	0.0	0.0	39.	29.	34.0	0.0	0.0	0.0	0.0	0.0023	1.6662	0.0043	3.2000
83	0.0	0.0	0.0	39.	25.	32.0	0.0	0.0	0.0	0.0	0.0001	0.0474	0.0037	2.7000
84	0.0	0.0	0.0	38.	24.	31.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0032	2.4000
85	0.02	0.02	0.04	36.	24.	30.0	0.02	0.020	0.0	0.020	0.0000	0.0082	0.0031	2.3000
86	0.0	0.0	0.0	35.	25.	30.0	0.00	0.0	0.017	0.017	0.0001	0.0417	0.0031	2.3000
87	0.16	0.30	0.46	35.	25.	30.0	0.03	0.160	0.273	0.433	0.0368	27.1820	0.0030	2.2000
88	0.0	0.0	0.0	31.	23.	27.0	0.03	0.0	0.0	0.0	0.0620	45.8347	0.0024	1.8000
89	0.0	0.0	0.0	25.	20.	22.5	0.03	0.0	0.0	0.0	0.0194	14.3804	0.0023	1.7000
90	0.0	0.0	0.0	31.	20.	25.5	0.03	0.0	0.0	0.0	0.0088	6.5425	0.0022	1.6000
91	0.0	0.0	0.0	30.	19.	24.5	0.03	0.0	0.0	0.0	0.0077	5.6566	0.0020	1.5000
92	0.0	0.24	0.24	27.	17.	22.0	0.27	0.0	0.0	0.0	0.0003	0.2254	0.0016	1.2000
93	0.0	0.06	0.06	28.	19.	23.5	0.33	0.0	0.0	0.0	0.0000	0.0135	0.0014	1.0000
94	0.0	0.0	0.0	26.	16.	21.0	0.33	0.0	0.0	0.0	0.0000	0.0002	0.0012	0.9000
95	0.0	0.0	0.0	27.	19.	23.0	0.33	0.0	0.0	0.0	0.0	0.0	0.0011	0.8000
96	0.0	0.0	0.0	32.	11.	21.5	0.33	0.0	0.0	0.0	0.0	0.0	0.0012	0.9000
97	0.34	0.0	0.34	37.	30.	33.5	0.0	0.340	0.330	0.670	0.0748	55.3109	0.0022	1.6000
98	0.10	0.0	0.10	41.	33.	37.0	0.0	0.100	0.0	0.100	0.1325	97.9873	0.0091	6.7000
99	0.0	0.0	0.0	43.	35.	39.0	0.0	0.0	0.0	0.0	0.1237	91.4744	0.0744	54.9999
100	0.0	0.0	0.0	43.	31.	37.0	0.0	0.0	0.0	0.0	0.0737	54.4875	0.0257	19.0000
101	0.01	0.0	0.01	43.	34.	38.5	0.0	0.010	0.0	0.010	0.0309	22.8584	0.0116	8.6000
102	0.0	0.0	0.0	42.	33.	37.5	0.0	0.0	0.0	0.0	0.0082	6.0987	0.0091	6.7000
103	0.0	0.0	0.0	45.	36.	40.5	0.0	0.0	0.0	0.0	0.0009	0.6803	0.0091	6.7000
104	0.0	0.0	0.0	44.	31.	37.5	0.0	0.0	0.0	0.0	0.0001	0.0803	0.0082	6.1000
105	0.0	0.0	0.0	43.	33.	38.0	0.0	0.0	0.0	0.0	0.0000	0.0081	0.0070	5.2000
106	0.20	0.0	0.20	51.	36.	43.5	0.0	0.200	0.0	0.200	0.0132	9.7912	0.0089	6.6000
107	0.0	0.0	0.0	49.	39.	44.0	0.0	0.0	0.0	0.0	0.0170	12.5363	0.0104	7.7000
108	0.12	0.0	0.12	47.	40.	43.5	0.0	0.120	0.0	0.120	0.0169	12.4976	0.0097	7.2000
109	0.0	0.0	0.0	45.	32.	38.5	0.0	0.0	0.0	0.0	0.0092	6.8381	0.0087	6.4000
110	0.0	0.0	0.0	45.	29.	37.0	0.0	0.0	0.0	0.0	0.0001	0.0717	0.0066	4.9000

Table 12 continued

DAILY SUMMARIES OF SNOW FOR YEAR 1961

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
111	0.0	0.0	0.0	42.	30.	36.0	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0053	3.9000
112	0.0	0.0	0.0	44.	26.	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0043	3.2000
113	0.0	0.0	0.0	35.	21.	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0039	2.9000
114	0.0	0.0	0.0	28.	23.	25.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0038	2.8000
115	0.0	0.0	0.0	29.	22.	25.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0034	2.5000
116	0.0	0.0	0.0	29.	23.	26.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0030	2.2000
117	0.0	0.0	0.0	32.	27.	29.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0028	2.1000
118	0.0	0.0	0.0	35.	19.	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0024	1.8000
119	0.0	0.0	0.0	32.	15.	23.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0020	1.5000
120	0.0	0.27	0.27	33.	20.	26.5	0.27	0.0	0.0	0.0	0.0	0.0	0.0018	1.3000
121	0.24	0.29	0.53	35.	26.	30.5	0.06	0.240	0.503	0.743	0.0763	56.3976	0.0020	1.5000
122	0.18	0.24	0.42	45.	30.	37.5	0.0	0.180	0.297	0.477	0.2017	149.1681	0.0134	9.9000
123	0.23	0.0	0.23	44.	36.	40.0	0.0	0.230	0.0	0.230	0.2332	172.4100	0.1501	111.0000
124	0.09	0.0	0.09	44.	32.	38.0	0.0	0.090	0.0	0.090	0.2049	151.4712	0.0514	38.0000
125	0.24	0.0	0.24	46.	37.	41.5	0.0	0.240	0.0	0.240	0.1818	134.4323	0.1312	97.0000
126	0.14	0.0	0.14	43.	31.	37.0	0.0	0.140	0.0	0.140	0.1530	113.1452	0.0460	34.0000
127	0.08	0.0	0.08	41.	35.	38.0	0.0	0.080	0.0	0.080	0.1129	83.4479	0.0568	42.0000
128	0.11	0.0	0.11	44.	37.	40.5	0.0	0.110	0.0	0.110	0.0829	61.2976	0.0487	36.0000
129	0.40	0.0	0.40	45.	40.	42.5	0.0	0.400	0.0	0.400	0.0645	47.6620	0.0595	44.0000
130	0.0	0.0	0.0	44.	29.	36.5	0.0	0.0	0.0	0.0	0.0646	47.7980	0.0717	52.9999
131	0.17	0.01	0.18	45.	33.	39.0	0.0	0.170	0.010	0.180	0.0960	70.9748	0.0365	27.0000
132	1.04	0.0	1.04	47.	34.	40.5	0.0	1.040	0.0	1.040	0.1986	146.8241	0.1352	100.0000
133	0.79	0.0	0.79	48.	43.	45.5	0.0	0.790	0.0	0.790	0.3991	295.1018	0.3814	281.9998
134	0.29	0.0	0.29	48.	40.	44.0	0.0	0.290	0.0	0.290	0.4022	297.4258	0.2799	206.9998
135	0.02	0.0	0.02	45.	32.	38.5	0.0	0.020	0.0	0.020	0.3580	264.6855	0.1501	111.0000
136	0.50	0.0	0.50	41.	31.	36.0	0.0	0.500	0.0	0.500	0.2490	184.0885	0.1609	119.0000
137	0.02	0.0	0.02	42.	33.	37.5	0.0	0.020	0.0	0.020	0.2558	189.1447	0.1420	104.9999
138	0.25	0.0	0.25	49.	35.	42.0	0.0	0.250	0.0	0.250	0.1906	140.9064	0.1542	114.0000
139	0.0	0.0	0.0	43.	31.	37.0	0.0	0.0	0.0	0.0	0.1284	94.9082	0.0825	60.9999
140	0.08	0.02	0.10	37.	30.	33.5	0.0	0.080	0.021	0.101	0.1209	89.4110	0.0649	47.9999
141	0.15	0.10	0.25	38.	29.	33.5	0.10	0.150	0.0	0.150	0.0731	54.0409	0.0568	42.0000
142	0.16	0.36	0.53	48.	31.	39.5	0.0	0.165	0.465	0.630	0.1588	117.4549	0.1907	141.0000
143	0.20	0.0	0.20	53.	41.	47.0	0.0	0.200	0.0	0.200	0.1799	132.9975	0.1663	123.0000
144	0.57	0.0	0.57	49.	44.	46.5	0.0	0.570	0.0	0.570	0.1981	146.4816	0.2732	201.9998
145	0.0	0.0	0.0	45.	31.	38.0	0.0	0.0	0.0	0.0	0.2184	161.4653	0.1461	108.0000
146	0.0	0.0	0.0	44.	29.	36.5	0.0	0.0	0.0	0.0	0.1556	115.0771	0.0771	57.0000
147	0.04	0.0	0.04	49.	36.	42.5	0.0	0.040	0.0	0.040	0.0886	65.5061	0.0595	44.0000
148	0.0	0.0	0.0	41.	30.	35.5	0.0	0.0	0.0	0.0	0.0461	34.0725	0.0446	33.0000
149	0.0	0.01	0.01	41.	29.	35.0	0.0	0.0	0.010	0.010	0.0206	15.1954	0.0365	27.0000
150	0.11	0.12	0.24	37.	30.	33.5	0.0	0.115	0.125	0.240	0.0240	17.7256	0.0649	47.9999
151	0.01	0.0	0.01	43.	27.	35.0	0.0	0.010	0.0	0.010	0.0319	23.6165	0.0649	47.9999
152	0.64	0.09	0.73	45.	33.	39.0	0.0	0.640	0.090	0.730	0.1075	79.4795	0.2664	196.9998
153	0.01	0.01	0.02	38.	29.	33.5	0.01	0.010	0.0	0.010	0.1528	112.9733	0.0825	60.9999
154	0.0	0.0	0.0	35.	22.	28.5	0.0	0.0	0.010	0.010	0.0990	73.2382	0.0649	47.9999
155	0.0	0.0	0.0	37.	23.	30.0	0.0	0.0	0.0	0.0	0.0512	37.8466	0.0406	30.0000
156	0.13	0.0	0.13	37.	25.	31.0	0.0	0.130	0.0	0.130	0.0231	17.0551	0.0298	22.0000
157	0.10	0.0	0.10	43.	32.	37.5	0.0	0.100	0.0	0.100	0.0202	14.9057	0.0744	54.9999
158	0.0	0.0	0.0	46.	31.	38.5	0.0	0.0	0.0	0.0	0.0136	10.0312	0.0541	40.0000
159	0.0	0.0	0.0	48.	32.	40.0	0.0	0.0	0.0	0.0	0.0015	1.1128	0.0325	24.0000
160	0.02	0.11	0.13	45.	31.	38.0	0.0	0.020	0.110	0.130	0.0071	5.2574	0.0744	54.9999
161	0.0	0.0	0.0	43.	31.	37.0	0.0	0.0	0.0	0.0	0.0051	3.7433	0.0446	33.0000
162	0.04	0.16	0.21	42.	29.	35.5	0.0	0.045	0.165	0.210	0.0174	12.8975	0.0487	36.0000
163	0.24	0.0	0.24	43.	30.	36.5	0.0	0.240	0.0	0.240	0.0294	21.7389	0.0703	51.9999
164	0.39	0.0	0.39	48.	38.	43.0	0.0	0.390	0.0	0.390	0.0587	43.3776	0.1582	117.0000
165	0.22	0.0	0.22	57.	42.	49.5	0.0	0.220	0.0	0.220	0.1081	79.9153	0.2434	179.9998

Table 13. Daily summary of some rainy and snowmelt seasons (Missouri Flat Creek watershed in 1962)

DAILY SUMMARIES OF SNOW FOR YEAR 1962

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
56	0.0	0.23	0.23	31.	25.	28.0	1.91	0.0	0.0	0.0	0.0	0.0	0.0011	0.8000
57	0.0	0.02	0.02	36.	17.	26.5	1.86	0.0	0.071	0.071	0.0	0.0	0.0011	0.8000
58	0.0	0.0	0.0	40.	33.	36.5	1.49	0.0	0.375	0.375	0.0	0.0	0.0018	1.3000
59	0.0	0.0	0.0	41.	35.	38.0	0.96	0.0	0.528	0.528	0.0	0.0	0.0020	1.5000
60	0.06	0.0	0.06	42.	36.	39.0	0.22	0.060	0.730	0.790	0.0006	0.4148	0.0022	1.6000
61	0.05	0.0	0.05	47.	34.	40.5	0.0	0.050	0.224	0.274	0.0	0.0	0.0023	1.7000
62	0.0	0.0	0.0	45.	32.	38.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0019	1.4000
63	0.02	0.0	0.02	43.	36.	39.5	0.0	0.020	0.0	0.020	0.0	0.0	0.0016	1.2000
64	0.07	0.0	0.07	40.	33.	36.5	0.0	0.070	0.0	0.070	0.0	0.0	0.0018	1.3000
65	0.23	0.0	0.23	44.	29.	36.5	0.0	0.230	0.0	0.230	0.0004	0.3241	0.0016	1.2000
66	0.0	0.0	0.0	47.	31.	39.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0019	1.4000
67	0.0	0.0	0.0	33.	27.	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0014	1.0000
68	0.0	0.43	0.43	31.	23.	27.0	0.43	0.0	0.0	0.0	0.0	0.0	0.0011	0.8000
69	0.0	0.03	0.03	28.	19.	23.5	0.46	0.0	0.0	0.0	0.0	0.0	0.0009	0.7000
70	0.0	0.0	0.0	24.	13.	18.5	0.46	0.0	0.0	0.0	0.0	0.0	0.0008	0.6000
71	0.0	0.0	0.0	15.	-9.	3.0	0.46	0.0	0.0	0.0	0.0	0.0	0.0007	0.5000
72	0.0	0.0	0.0	12.	-12.	0.0	0.46	0.0	0.0	0.0	0.0	0.0	0.0005	0.4000
73	0.0	0.02	0.02	19.	10.	14.5	0.48	0.0	0.0	0.0	0.0	0.0	0.0005	0.4000
74	0.0	0.0	0.0	25.	15.	20.0	0.48	0.0	0.0	0.0	0.0	0.0	0.0005	0.4000
75	0.0	0.18	0.18	28.	22.	25.0	0.66	0.0	0.0	0.0	0.0	0.0	0.0005	0.4000
76	0.0	0.27	0.27	31.	20.	25.5	0.93	0.0	0.0	0.0	0.0	0.0	0.0005	0.4000
77	0.0	0.17	0.17	31.	24.	27.5	1.10	0.0	0.0	0.0	0.0	0.0	0.0007	0.5000
78	0.12	0.25	0.38	39.	29.	34.0	0.94	0.125	0.410	0.535	0.0066	4.8947	0.0011	0.8000
79	0.0	0.04	0.04	33.	21.	27.0	0.98	0.0	0.0	0.0	0.0	0.0	0.0008	0.6000
80	0.27	0.30	0.57	38.	29.	33.5	0.52	0.270	0.762	1.032	0.0982	72.6048	0.0046	3.4000
81	0.32	0.0	0.32	46.	35.	40.5	0.0	0.320	0.518	0.838	0.0660	48.8183	0.0097	7.2000
82	0.0	0.0	0.0	46.	30.	38.0	0.0	0.0	0.0	0.0	0.0541	39.9743	0.0149	11.0000
83	0.0	0.08	0.08	36.	25.	30.5	0.08	0.0	0.0	0.0	0.0157	11.5905	0.0080	5.9000
84	0.0	0.03	0.03	40.	32.	36.0	0.0	0.0	0.112	0.112	0.0041	3.0224	0.0080	5.9000
85	0.40	0.0	0.40	44.	37.	40.5	0.0	0.400	0.0	0.400	0.0193	14.2726	0.0203	15.0000
86	0.0	0.03	0.03	39.	28.	33.5	0.03	0.0	0.0	0.0	0.0138	10.1905	0.0149	11.0000
87	0.0	0.03	0.03	32.	28.	30.0	0.06	0.0	0.0	0.0	0.0021	1.5894	0.0076	5.6000
88	0.0	0.0	0.0	31.	19.	25.0	0.06	0.0	0.0	0.0	0.0004	0.2616	0.0057	4.2000
89	0.05	0.12	0.17	39.	29.	34.0	0.0	0.050	0.180	0.230	0.0080	5.9466	0.0057	4.2000
90	0.03	0.0	0.03	46.	36.	41.0	0.0	0.030	0.0	0.030	0.0079	5.8274	0.0084	6.2000
91	0.0	0.0	0.0	45.	31.	38.0	0.0	0.0	0.0	0.0	0.0009	0.6477	0.0203	15.0000
92	0.0	0.0	0.0	40.	33.	36.5	0.0	0.0	0.0	0.0	0.0000	0.0315	0.0091	6.7000
93	0.0	0.0	0.0	40.	31.	35.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0073	5.4000
94	0.0	0.0	0.0	40.	25.	32.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0061	4.5000
95	0.27	0.0	0.27	44.	37.	40.5	0.0	0.270	0.0	0.270	0.0199	14.7108	0.0149	11.0000
96	0.0	0.0	0.0	40.	29.	34.5	0.0	0.0	0.0	0.0	0.0241	17.7863	0.0189	14.0000
97	0.0	0.0	0.0	41.	32.	36.5	0.0	0.0	0.0	0.0	0.0245	18.1286	0.0091	6.7000
98	0.12	0.0	0.12	46.	32.	39.0	0.0	0.120	0.0	0.120	0.0101	7.4830	0.0092	6.8000
99	0.05	0.21	0.26	50.	30.	40.0	0.0	0.050	0.211	0.261	0.0364	26.9136	0.0379	28.0000
100	0.0	0.11	0.11	50.	29.	39.5	0.0	0.0	0.110	0.110	0.0610	45.1089	0.0298	22.0000
101	0.0	0.0	0.0	30.	19.	24.5	0.0	0.0	0.0	0.0	0.0481	35.5501	0.0081	6.0000
102	0.0	0.0	0.0	26.	15.	20.5	0.0	0.0	0.0	0.0	0.0069	5.1316	0.0047	3.5000
103	0.0	0.0	0.0	30.	19.	24.5	0.0	0.0	0.0	0.0	0.0037	2.7447	0.0034	2.5000
104	0.0	0.09	0.09	29.	19.	24.0	0.09	0.0	0.0	0.0	0.0025	1.8655	0.0028	2.1000
105	0.0	0.02	0.02	22.	17.	19.5	0.11	0.0	0.0	0.0	0.0003	0.2203	0.0028	2.1000
106	0.0	0.32	0.32	30.	11.	20.5	0.43	0.0	0.0	0.0	0.0000	0.0027	0.0027	2.0000
107	0.0	0.02	0.02	30.	9.	19.5	0.45	0.0	0.0	0.0	0.0	0.0	0.0022	1.6000
108	0.0	0.0	0.0	34.	5.	19.5	0.45	0.0	0.0	0.0	0.0	0.0	0.0019	1.4000
109	0.0	0.30	0.30	29.	19.	24.0	0.75	0.0	0.0	0.0	0.0000	0.0000	0.0016	1.2000
110	0.0	0.0	0.0	20.	3.	11.5	0.75	0.0	0.0	0.0	0.0	0.0	0.0015	1.1000

DAILY SUMMARIES OF SNOW FOR YEAR 1962

	PRECIPITATION(IN)			TEMPERATURE(F)			SWE ON	AVAILABLE MOISTURE(IN)			SIMULATED RUNOFF		OBSERVED RUNOFF	
DAY	RAIN	SNOW	TOT	MAX	MIN	MEAN	GROUND	RAIN	SNOW	TOTAL	(IN)	(CFS)	(IN)	(CFS)
111	0.0	0.0	0.0	15.	0.	7.5	0.75	0.0	0.0	0.0	0.0	0.0	0.0014	1.0000
112	0.0	0.0	0.0	13.	6.	9.5	0.75	0.0	0.0	0.0	0.0	0.0	0.0015	1.1000
113	0.0	0.0	0.0	13.	-9.	2.0	0.75	0.0	0.0	0.0	0.0	0.0	0.0016	1.2000
114	0.0	0.0	0.0	12.	-4.	4.0	0.75	0.0	0.0	0.0	0.0	0.0	0.0019	1.4000
115	0.0	0.0	0.0	18.	5.	11.5	0.75	0.0	0.0	0.0	0.0	0.0	0.0022	1.6000
116	0.0	0.01	0.01	28.	17.	22.5	0.76	0.0	0.0	0.0	0.0	0.0	0.0024	1.8000
117	0.0	0.0	0.0	43.	23.	33.0	0.20	0.0	0.561	0.561	0.0195	14.4217	0.0027	2.0000
118	0.01	0.0	0.01	46.	39.	42.5	0.0	0.010	0.196	0.206	0.1336	98.8078	0.0041	3.0000
119	0.0	0.0	0.0	46.	38.	42.0	0.0	0.0	0.0	0.0	0.1359	100.4879	0.0055	4.1000
120	0.0	0.0	0.0	47.	33.	40.0	0.0	0.0	0.0	0.0	0.0849	62.8028	0.0066	4.9000
121	0.0	0.0	0.0	46.	34.	40.0	0.0	0.0	0.0	0.0	0.0374	27.6432	0.0072	5.3000
122	0.0	0.0	0.0	48.	35.	41.5	0.0	0.0	0.0	0.0	0.0110	8.1173	0.0076	5.6000
123	0.0	0.0	0.0	45.	32.	38.5	0.0	0.0	0.0	0.0	0.0014	1.0522	0.0085	6.3000
124	0.0	0.0	0.0	50.	35.	42.5	0.0	0.0	0.0	0.0	0.0002	0.1333	0.0088	6.5000
125	0.0	0.0	0.0	52.	36.	44.0	0.0	0.0	0.0	0.0	0.0000	0.0193	0.0088	6.5000
126	0.0	0.0	0.0	53.	35.	44.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0087	6.4000
127	0.0	0.0	0.0	45.	33.	39.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0081	6.0000
128	0.0	0.0	0.0	41.	24.	32.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0069	5.1000
129	0.23	0.0	0.23	41.	27.	34.0	0.0	0.230	0.0	0.230	0.0023	1.7301	0.0070	5.2000
130	0.07	0.0	0.07	45.	32.	38.5	0.0	0.070	0.0	0.070	0.0201	14.8397	0.0104	7.7000
131	0.05	0.0	0.05	52.	36.	44.0	0.0	0.050	0.0	0.050	0.0204	15.0513	0.0104	7.7000
132	0.05	0.0	0.05	45.	35.	40.0	0.0	0.050	0.0	0.050	0.0089	6.5997	0.0084	6.2000
133	0.0	0.0	0.0	48.	38.	43.0	0.0	0.0	0.0	0.0	0.0007	0.5542	0.0076	5.6000
134	0.03	0.02	0.05	48.	33.	40.5	0.0	0.030	0.020	0.050	0.0002	0.1333	0.0060	4.4000
135	0.05	0.20	0.26	45.	33.	39.0	0.0	0.055	0.204	0.259	0.0259	19.1612	0.0135	10.0000
136	0.25	0.0	0.25	47.	36.	41.5	0.0	0.250	0.0	0.250	0.0537	39.7219	0.0131	9.7000
137	0.0	0.0	0.0	45.	37.	41.0	0.0	0.0	0.0	0.0	0.0654	48.3428	0.0123	9.1000
138	0.0	0.0	0.0	40.	32.	36.0	0.0	0.0	0.0	0.0	0.0396	29.2681	0.0078	5.8000
139	0.02	0.0	0.02	49.	34.	41.5	0.0	0.020	0.0	0.020	0.0145	10.7100	0.0081	6.0000
140	0.15	0.0	0.15	42.	35.	38.5	0.0	0.150	0.0	0.150	0.0165	12.1976	0.0116	8.6000
141	0.0	0.0	0.0	47.	35.	41.0	0.0	0.0	0.0	0.0	0.0113	8.3406	0.0097	7.2000
142	0.0	0.0	0.0	47.	31.	39.0	0.0	0.0	0.0	0.0	0.0006	0.4377	0.0078	5.8000
143	0.0	0.0	0.0	43.	28.	35.5	0.0	0.0	0.0	0.0	0.0001	0.0989	0.0066	4.9000
144	0.0	0.0	0.0	35.	21.	28.0	0.0	0.0	0.0	0.0	0.0002	0.1313	0.0054	4.0000
145	0.0	0.16	0.16	36.	27.	31.5	0.12	0.0	0.040	0.040	0.0001	0.0577	0.0049	3.6000
146	0.0	0.0	0.0	30.	13.	21.5	0.12	0.0	0.0	0.0	0.0001	0.0404	0.0034	2.5000
147	0.0	0.0	0.0	24.	6.	15.0	0.12	0.0	0.0	0.0	0.0	0.0	0.0022	1.6000
148	0.0	0.0	0.0	24.	6.	15.0	0.12	0.0	0.0	0.0	0.0	0.0	0.0015	1.1000
149	0.0	0.0	0.0	21.	-2.	9.5	0.12	0.0	0.0	0.0	0.0	0.0	0.0011	0.8000
150	0.0	0.0	0.0	25.	2.	13.5	0.12	0.0	0.0	0.0	0.0	0.0	0.0011	0.8000
151	0.0	0.16	0.16	31.	15.	23.0	0.28	0.0	0.0	0.0	0.0	0.0	0.0012	0.9000
152	0.0	0.20	0.20	32.	21.	26.5	0.48	0.0	0.0	0.0	0.0	0.0	0.0014	1.0000
153	0.0	0.16	0.16	31.	11.	21.0	0.64	0.0	0.0	0.0	0.0	0.0	0.0014	1.0000
154	0.0	0.02	0.02	30.	20.	25.0	0.66	0.0	0.0	0.0	0.0	0.0	0.0014	1.0000
155	0.01	0.25	0.26	37.	26.	31.5	0.74	0.010	0.167	0.177	0.0035	2.5728	0.0020	1.5000
156	0.0	0.0	0.0	44.	34.	39.0	0.10	0.0	0.638	0.638	0.0453	33.5186	0.0034	2.5000
157	0.0	0.0	0.0	45.	34.	39.5	0.0	0.0	0.103	0.103	0.1430	105.7254	0.0081	6.0000
158	0.0	0.0	0.0	44.	33.	38.5	0.0	0.0	0.0	0.0	0.1309	96.8079	0.0189	14.0000
159	0.05	0.0	0.05	43.	30.	36.5	0.0	0.050	0.0	0.050	0.0784	58.0009	0.0284	21.0000
160	0.0	0.01	0.01	35.	18.	26.5	0.01	0.0	0.0	0.0	0.0356	26.3296	0.0230	17.0000
161	0.0	0.10	0.10	34.	22.	28.0	0.11	0.0	0.0	0.0	0.0075	5.5098	0.0131	9.7000
162	0.02	0.13	0.15	38.	24.	31.0	0.09	0.020	0.150	0.170	0.0068	5.0268	0.0092	6.8000
163	0.0	0.0	0.0	35.	23.	29.0	0.07	0.0	0.016	0.016	0.0133	9.8448	0.0074	5.5000
164	0.0	0.0	0.0	40.	22.	31.0	0.0	0.0	0.074	0.074	0.0058	4.3100	0.0101	7.5000
165	0.0	0.0	0.0	47.	28.	37.5	0.0	0.0	0.0	0.0	0.0032	2.3995	0.0118	8.7000

Table 13 continued

DAILY SUMMARIES OF SNOW FOR YEAR 1962

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
166	0.0	0.0	0.0	52.	31.	41.5	0.0	0.0	0.0	0.0	0.0006	0.4658	0.0189	14.0000
167	0.0	0.0	0.0	53.	31.	42.0	0.0	0.0	0.0	0.0	0.0002	0.1244	0.0176	13.0000
168	0.0	0.0	0.0	54.	30.	42.0	0.0	0.0	0.0	0.0	0.0001	0.0486	0.0131	9.7000
169	0.0	0.0	0.0	50.	33.	41.5	0.0	0.0	0.0	0.0	0.0000	0.0008	0.0097	7.2000
170	0.04	0.0	0.04	45.	34.	39.5	0.0	0.040	0.0	0.040	0.0	0.0	0.0089	6.6000
171	0.13	0.0	0.13	43.	35.	39.0	0.0	0.130	0.0	0.130	0.0003	0.2324	0.0149	11.0000
172	0.0	0.0	0.0	40.	27.	33.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0116	8.6000
173	0.34	0.03	0.37	40.	32.	36.0	0.0	0.340	0.031	0.371	0.0302	22.3539	0.0189	14.0000
174	0.0	0.0	0.0	45.	28.	36.5	0.0	0.0	0.0	0.0	0.0571	42.2573	0.0176	13.0000
175	0.71	0.15	0.86	41.	33.	37.0	0.0	0.710	0.150	0.860	0.0876	64.7824	0.0757	55.9999
176	0.53	0.0	0.53	49.	37.	43.0	0.0	0.530	0.0	0.530	0.2891	213.7856	0.2272	168.0000
177	0.48	0.0	0.48	46.	41.	43.5	0.0	0.485	0.0	0.485	0.2929	216.5666	0.1420	104.9999
178	0.06	0.05	0.11	42.	33.	37.5	0.0	0.065	0.050	0.115	0.2824	208.8382	0.1542	114.0000
179	0.0	0.0	0.0	43.	27.	35.0	0.0	0.0	0.0	0.0	0.2188	161.7659	0.0676	50.0000
180	0.0	0.0	0.0	52.	26.	39.0	0.0	0.0	0.0	0.0	0.1331	98.4138	0.0379	28.0000
181	0.0	0.0	0.0	56.	30.	43.0	0.0	0.0	0.0	0.0	0.0649	47.9786	0.0270	20.0000
182	0.0	0.0	0.0	60.	30.	45.0	0.0	0.0	0.0	0.0	0.0254	18.8037	0.0189	14.0000
183	0.0	0.0	0.0	61.	33.	47.0	0.0	0.0	0.0	0.0	0.0062	4.5683	0.0176	13.0000
184	0.0	0.0	0.0	59.	33.	46.0	0.0	0.0	0.0	0.0	0.0013	0.9838	0.0162	12.0000
185	0.0	0.0	0.0	60.	33.	46.5	0.0	0.0	0.0	0.0	0.0004	0.3022	0.0149	11.0000
186	0.28	0.0	0.28	60.	34.	47.0	0.0	0.280	0.0	0.280	0.0024	1.7719	0.0116	8.6000
187	0.0	0.0	0.0	58.	41.	49.5	0.0	0.0	0.0	0.0	0.0032	2.3685	0.0123	9.1000
188	0.28	0.0	0.28	55.	45.	50.0	0.0	0.280	0.0	0.280	0.0146	10.7869	0.0216	16.0000
189	0.0	0.0	0.0	50.	36.	43.0	0.0	0.0	0.0	0.0	0.0191	14.1191	0.0189	14.0000
190	0.0	0.0	0.0	45.	29.	37.0	0.0	0.0	0.0	0.0	0.0182	13.4547	0.0123	9.1000
191	0.0	0.03	0.03	50.	29.	39.5	0.0	0.0	0.030	0.030	0.0043	3.1458	0.0089	6.6000
192	0.0	0.0	0.0	49.	31.	40.0	0.0	0.0	0.0	0.0	0.0002	0.1484	0.0072	5.3000
193	0.0	0.0	0.0	59.	30.	44.5	0.0	0.0	0.0	0.0	0.0001	0.0590	0.0061	4.5000
194	0.0	0.0	0.0	67.	39.	53.0	0.0	0.0	0.0	0.0	0.0000	0.0031	0.0054	4.0000
195	0.0	0.0	0.0	74.	38.	56.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0055	4.1000
196	0.0	0.0	0.0	80.	51.	65.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0050	3.7000
197	0.09	0.0	0.09	60.	40.	50.0	0.0	0.090	0.0	0.090	0.0	0.0	0.0046	3.4000
198	0.0	0.0	0.0	63.	32.	47.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0046	3.4000
199	0.0	0.0	0.0	72.	41.	56.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0041	3.0000
200	0.0	0.0	0.0	77.	41.	59.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0037	2.7000
201	0.0	0.0	0.0	61.	53.	57.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0034	2.5000
202	0.0	0.0	0.0	55.	37.	46.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0030	2.2000
203	0.0	0.0	0.0	59.	34.	46.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0037	2.7000
204	0.0	0.0	0.0	71.	41.	56.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0024	1.8000
205	0.0	0.0	0.0	78.	46.	62.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0023	1.7000
206	0.0	0.0	0.0	66.	45.	55.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0019	1.4000
207	0.0	0.0	0.0	55.	34.	44.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0019	1.4000
208	0.0	0.0	0.0	54.	29.	41.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0019	1.4000
209	0.99	0.0	0.99	50.	38.	44.0	0.0	0.990	0.0	0.990	0.0	0.0	0.0078	5.8000
210	0.0	0.0	0.0	46.	31.	38.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0076	5.6000
211	0.0	0.0	0.0	51.	31.	41.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0041	3.0000
212	0.0	0.0	0.0	60.	31.	45.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0032	2.4000
213	0.02	0.0	0.02	62.	41.	51.5	0.0	0.020	0.0	0.020	0.0	0.0	0.0030	2.2000
214	0.06	0.0	0.06	58.	46.	52.0	0.0	0.060	0.0	0.060	0.0	0.0	0.0032	2.4000
215	0.23	0.0	0.23	51.	40.	45.5	0.0	0.230	0.0	0.230	0.0	0.0	0.0041	3.0000
216	0.0	0.0	0.0	51.	29.	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0042	3.1000
217	0.0	0.0	0.0	56.	30.	43.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0032	2.4000
218	0.18	0.0	0.18	53.	43.	48.0	0.0	0.185	0.0	0.185	0.0000	0.0129	0.0031	2.3000
219	0.25	0.0	0.25	49.	36.	42.5	0.0	0.255	0.0	0.255	0.0134	9.9377	0.0055	4.1000
220	0.18	0.0	0.18	66.	42.	54.0	0.0	0.180	0.0	0.180	0.0055	4.0834	0.0050	3.7000

Table 14. Daily summary of some rainy and snowmelt seasons (Missouri Flat Creek watershed in 1963)

DAILY SUMMARIES OF SNOW FOR YEAR 1963

	PRECIPITATION(IN)			TEMPERATURE(F)			SWE ON	AVAILABLE MOISTURE(IN)			SIMULATED RUNOFF		OBSERVED RUNOFF	
DAY	RAIN	SNOW	TOT	MAX	MIN	MEAN	GROUND	RAIN	SNOW	TOTAL	(IN)	(CFS)	(IN)	(CFS)
111	0.0	0.0	0.0	15.	1.	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0005	0.4000
112	0.0	0.0	0.0	30.	11.	20.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0004	0.3000
113	0.0	0.0	0.0	35.	19.	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0004	0.3000
114	0.0	0.0	0.0	36.	16.	26.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0004	0.3000
115	0.0	0.0	0.0	30.	13.	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0004	0.3000
116	0.0	0.02	0.02	25.	21.	23.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0004	0.3000
117	0.0	0.0	0.0	28.	11.	19.5	0.02	0.0	0.0	0.0	0.0	0.0	0.0004	0.3000
118	0.0	0.0	0.0	25.	0.	12.5	0.02	0.0	0.0	0.0	0.0	0.0	0.0004	0.3000
119	0.0	0.0	0.0	24.	9.	16.5	0.02	0.0	0.0	0.0	0.0	0.0	0.0004	0.3000
120	0.0	0.0	0.0	22.	9.	15.5	0.02	0.0	0.0	0.0	0.0	0.0	0.0004	0.3000
121	0.0	0.02	0.02	20.	7.	13.5	0.04	0.0	0.0	0.0	0.0	0.0	0.0003	0.2000
122	0.0	0.05	0.05	19.	1.	10.0	0.09	0.0	0.0	0.0	0.0	0.0	0.0003	0.2000
123	0.0	0.47	0.47	32.	10.	21.0	0.56	0.0	0.0	0.0	0.0	0.0	0.0003	0.2000
124	0.0	0.48	0.48	33.	13.	23.0	1.04	0.0	0.0	0.0	0.0	0.0	0.0004	0.3000
125	0.18	0.13	0.32	38.	26.	32.0	0.57	0.185	0.603	0.788	0.0417	30.8461	0.0005	0.4000
126	0.63	0.0	0.63	48.	36.	42.0	0.0	0.630	0.571	1.201	0.5082	375.7517	0.6762	500.0000
127	0.31	0.0	0.31	56.	40.	48.0	0.0	0.310	0.0	0.310	0.4572	338.0288	0.2908	214.9998
128	0.0	0.0	0.0	53.	35.	44.0	0.0	0.0	0.0	0.0	0.2427	179.4617	0.1339	98.9999
129	0.03	0.0	0.03	55.	44.	49.5	0.0	0.030	0.0	0.030	0.2109	155.9341	0.0325	24.0000
130	0.0	0.0	0.0	54.	36.	45.0	0.0	0.0	0.0	0.0	0.1395	103.1273	0.0230	17.0000
131	0.0	0.0	0.0	55.	37.	46.0	0.0	0.0	0.0	0.0	0.0717	53.0230	0.0135	10.0000
132	0.0	0.0	0.0	52.	29.	40.5	0.0	0.0	0.0	0.0	0.0288	21.2901	0.0103	7.6000
133	0.0	0.0	0.0	57.	29.	43.0	0.0	0.0	0.0	0.0	0.0076	5.5848	0.0093	6.9000
134	0.0	0.0	0.0	46.	30.	38.0	0.0	0.0	0.0	0.0	0.0012	0.9115	0.0093	6.9000
135	0.0	0.0	0.0	45.	28.	36.5	0.0	0.0	0.0	0.0	0.0003	0.2266	0.0074	5.5000
136	0.40	0.12	0.52	38.	29.	33.5	0.12	0.400	0.0	0.400	0.0077	5.7227	0.0069	5.1000
137	0.0	0.0	0.0	40.	30.	35.0	0.0	0.0	0.120	0.120	0.0687	50.8303	0.0080	5.9000
138	0.0	0.0	0.0	39.	27.	33.0	0.0	0.0	0.0	0.0	0.0718	53.0564	0.0074	5.5000
139	0.0	0.07	0.07	38.	31.	34.5	0.0	0.0	0.070	0.070	0.0417	30.8384	0.0203	15.0000
140	0.0	0.02	0.02	35.	29.	32.0	0.0	0.0	0.020	0.020	0.0186	13.7899	0.0270	20.0000
141	0.20	0.0	0.20	40.	32.	36.0	0.0	0.200	0.0	0.200	0.0112	8.2659	0.0663	48.9999
142	0.21	0.0	0.21	49.	36.	42.5	0.0	0.210	0.0	0.210	0.0503	37.2228	0.0784	57.9999
143	0.0	0.0	0.0	50.	30.	40.0	0.0	0.0	0.0	0.0	0.0563	41.6348	0.0230	17.0000
144	0.0	0.0	0.0	49.	29.	39.0	0.0	0.0	0.0	0.0	0.0275	20.3466	0.0135	10.0000
145	0.0	0.0	0.0	48.	31.	39.5	0.0	0.0	0.0	0.0	0.0071	5.2238	0.0093	6.9000
146	0.0	0.0	0.0	49.	31.	40.0	0.0	0.0	0.0	0.0	0.0013	0.9479	0.0080	5.9000
147	0.0	0.0	0.0	50.	29.	39.5	0.0	0.0	0.0	0.0	0.0004	0.3079	0.0074	5.5000
148	0.08	0.0	0.08	53.	30.	41.5	0.0	0.080	0.0	0.080	0.0003	0.1945	0.0069	5.1000
149	0.02	0.0	0.02	50.	41.	45.5	0.0	0.020	0.0	0.020	0.0009	0.6319	0.0089	6.6000
150	0.0	0.0	0.0	45.	33.	39.0	0.0	0.0	0.0	0.0	0.0001	0.0486	0.0065	4.8000
151	0.04	0.0	0.04	50.	31.	40.5	0.0	0.040	0.0	0.040	0.0000	0.0008	0.0053	3.9000
152	0.0	0.0	0.0	41.	31.	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0053	3.9000
153	0.01	0.0	0.01	41.	30.	35.5	0.0	0.010	0.0	0.010	0.0	0.0	0.0043	3.2000
154	0.0	0.0	0.0	40.	21.	30.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0037	2.7000
155	0.0	0.0	0.0	42.	22.	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0031	2.3000
156	0.0	0.01	0.01	41.	29.	35.0	0.0	0.0	0.010	0.010	0.0	0.0	0.0034	2.5000
157	0.0	0.0	0.0	48.	30.	39.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0034	2.5000
158	0.0	0.0	0.0	47.	25.	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0026	1.9000
159	0.0	0.0	0.0	53.	28.	40.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0023	1.7000
160	0.0	0.0	0.0	53.	29.	41.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0022	1.6000
161	0.03	0.0	0.03	47.	31.	39.0	0.0	0.030	0.0	0.030	0.0	0.0	0.0020	1.5000
162	0.05	0.0	0.05	46.	33.	39.5	0.0	0.050	0.0	0.050	0.0	0.0	0.0020	1.5000
163	0.0	0.0	0.0	45.	28.	36.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0018	1.3000
164	0.0	0.0	0.0	48.	28.	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0018	1.3000
165	0.01	0.01	0.02	44.	34.	39.0	0.01	0.010	0.0	0.010	0.0	0.0	0.0016	1.2000

Table 14 continued

DAILY SUMMARIES OF SNOW FOR YEAR 1963

DAY	PRECIPITATION(IN) RAIN	SNOW	TOT	TEMPERATURE(F) MAX	MIN	MEAN	SWE ON GROUND	AVAILABLE MOISTURE(IN) RAIN	SNOW	TOTAL	SIMULATED RUNOFF (IN)	(CFS)	OBSERVED RUNOFF (IN)	(CFS)
166	0.0	0.05	0.05	38.	28.	33.0	0.0	0.0	0.060	0.060	0.0	0.0	0.0019	1.4000
167	0.0	0.0	0.0	42.	27.	34.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0018	1.3000
168	0.0	0.0	0.0	49.	27.	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0014	1.0000
169	0.0	0.0	0.0	46.	30.	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0016	1.2000
170	0.04	0.0	0.04	44.	34.	39.0	0.0	0.040	0.0	0.040	0.0	0.0	0.0016	1.2000
171	0.0	0.0	0.0	61.	37.	49.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0016	1.2000
172	0.0	0.0	0.0	65.	44.	54.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0018	1.3000
173	0.0	0.0	0.0	62.	37.	49.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0015	1.1000
174	0.25	0.0	0.25	55.	40.	47.5	0.0	0.250	0.0	0.250	0.0	0.0	0.0023	1.7000
175	0.0	0.0	0.0	50.	32.	41.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0022	1.6000
176	0.0	0.0	0.0	64.	34.	49.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0022	1.6000
177	0.0	0.0	0.0	62.	29.	45.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0016	1.2000
178	0.18	0.0	0.18	50.	38.	44.0	0.0	0.180	0.0	0.180	0.0008	0.6170	0.0023	1.7000
179	0.10	0.0	0.10	54.	38.	46.0	0.0	0.100	0.0	0.100	0.0006	0.4097	0.0026	1.9000
180	0.66	0.0	0.66	50.	34.	42.0	0.0	0.660	0.0	0.660	0.0300	22.1826	0.0072	5.3000
181	0.62	0.07	0.69	52.	33.	42.5	0.0	0.620	0.070	0.690	0.2257	166.8576	0.0379	28.0000
182	0.0	0.0	0.0	45.	28.	36.5	0.0	0.0	0.0	0.0	0.2829	209.1979	0.0176	13.0000
183	0.0	0.0	0.0	41.	29.	35.0	0.0	0.0	0.0	0.0	0.1533	113.3391	0.0069	5.1000
184	0.0	0.0	0.0	47.	27.	37.0	0.0	0.0	0.0	0.0	0.1073	79.3466	0.0057	4.2000
185	0.05	0.0	0.05	52.	31.	41.5	0.0	0.050	0.0	0.050	0.0581	42.9350	0.0069	5.1000
186	0.01	0.0	0.01	55.	40.	47.5	0.0	0.010	0.0	0.010	0.0099	7.2911	0.0053	3.9000
187	0.28	0.0	0.28	53.	41.	47.0	0.0	0.280	0.0	0.280	0.0123	9.0933	0.0077	5.7000
188	0.09	0.0	0.09	51.	37.	44.0	0.0	0.090	0.0	0.090	0.0321	23.7203	0.0149	11.0000
189	0.10	0.0	0.10	50.	34.	42.0	0.0	0.100	0.0	0.100	0.0311	22.9793	0.0103	7.6000
190	0.17	0.0	0.17	49.	35.	42.0	0.0	0.170	0.0	0.170	0.0307	22.7112	0.0080	5.9000
191	0.0	0.0	0.0	52.	34.	43.0	0.0	0.0	0.0	0.0	0.0204	15.0689	0.0093	6.9000
192	0.0	0.0	0.0	52.	31.	41.5	0.0	0.0	0.0	0.0	0.0069	5.1381	0.0162	12.0000
193	0.0	0.0	0.0	55.	33.	44.0	0.0	0.0	0.0	0.0	0.0002	0.1375	0.0103	7.6000
194	0.0	0.0	0.0	60.	38.	49.0	0.0	0.0	0.0	0.0	0.0003	0.1983	0.0085	6.3000
195	0.0	0.0	0.0	66.	39.	52.5	0.0	0.0	0.0	0.0	0.0001	0.0834	0.0080	5.9000
196	0.27	0.0	0.27	75.	45.	60.0	0.0	0.270	0.0	0.270	0.0014	1.0430	0.0069	5.1000
197	0.04	0.02	0.06	45.	30.	37.5	0.0	0.040	0.020	0.060	0.0052	3.8435	0.0057	4.2000
198	0.0	0.0	0.0	43.	30.	36.5	0.0	0.0	0.0	0.0	0.0003	0.2199	0.0043	3.2000
199	0.0	0.02	0.02	50.	31.	40.5	0.0	0.0	0.020	0.020	0.0	0.0	0.0034	2.5000
200	0.04	0.0	0.04	45.	31.	38.0	0.0	0.040	0.0	0.040	0.0	0.0	0.0032	2.4000
201	0.19	0.0	0.19	47.	31.	39.0	0.0	0.190	0.0	0.190	0.0007	0.5065	0.0037	2.7000
202	0.0	0.44	0.44	45.	29.	37.0	0.0	0.0	0.438	0.438	0.0222	16.4212	0.0243	18.0000
203	0.0	0.0	0.0	49.	30.	39.5	0.0	0.0	0.0	0.0	0.0568	42.0016	0.0149	11.0000
204	0.03	0.0	0.03	49.	30.	39.5	0.0	0.030	0.0	0.030	0.0329	24.3236	0.0069	5.1000
205	0.0	0.0	0.0	52.	37.	44.5	0.0	0.0	0.0	0.0	0.0114	8.3967	0.0060	4.4000
206	0.0	0.0	0.0	61.	32.	46.5	0.0	0.0	0.0	0.0	0.0003	0.2112	0.0057	4.2000
207	0.0	0.0	0.0	58.	39.	48.5	0.0	0.0	0.0	0.0	0.0001	0.0582	0.0053	3.9000
208	0.04	0.0	0.04	52.	39.	45.5	0.0	0.040	0.0	0.040	0.0000	0.0000	0.0049	3.6000
209	0.0	0.0	0.0	56.	38.	47.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0049	3.6000
210	0.0	0.0	0.0	64.	33.	48.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0041	3.0000
211	0.0	0.0	0.0	63.	43.	53.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0023	1.7000
212	0.0	0.0	0.0	59.	35.	47.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0020	1.5000
213	0.0	0.0	0.0	49.	35.	42.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0030	2.2000
214	0.05	0.0	0.05	51.	37.	44.0	0.0	0.050	0.0	0.050	0.0	0.0	0.0057	4.2000
215	0.07	0.0	0.07	50.	35.	42.5	0.0	0.070	0.0	0.070	0.0	0.0	0.0057	4.2000
216	0.06	0.0	0.06	56.	30.	43.0	0.0	0.060	0.0	0.060	0.0	0.0	0.0060	4.4000
217	0.0	0.0	0.0	67.	44.	55.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0050	3.7000
218	0.02	0.0	0.02	59.	43.	51.0	0.0	0.020	0.0	0.020	0.0	0.0	0.0049	3.6000
219	0.15	0.0	0.15	55.	42.	48.5	0.0	0.150	0.0	0.150	0.0	0.0	0.0020	1.5000
220	0.0	0.0	0.0	54.	36.	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0023	1.7000

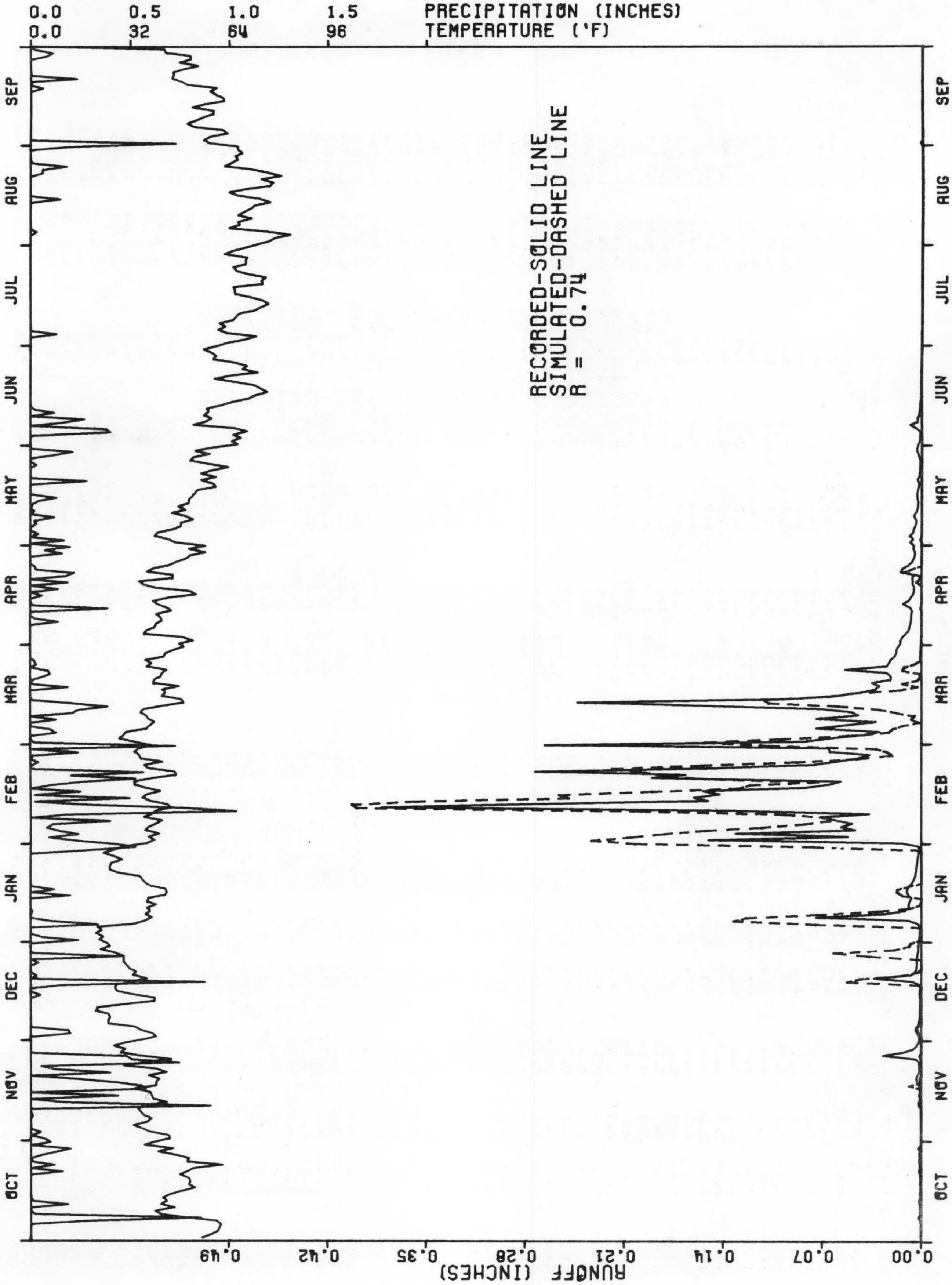

Figure 17. Precipitation, daily mean temperature and daily comparison of observed and simulated runoff (Missouri Flat Creek watershed in 1961)

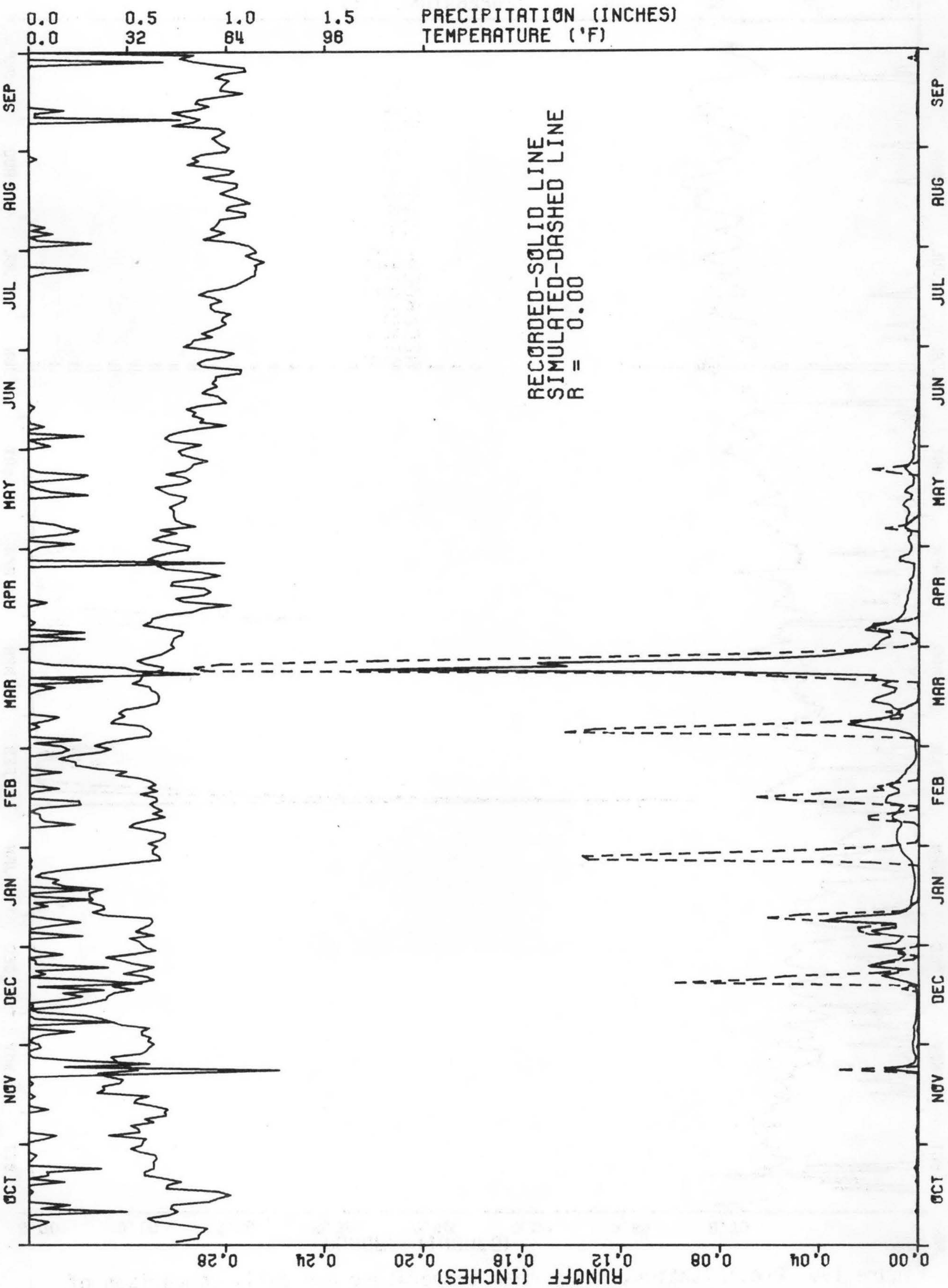

Figure 18. Precipitation, daily mean temperature and daily comparison of observed and simulated runoff (Missouri Flat Creek watershed in 1962).

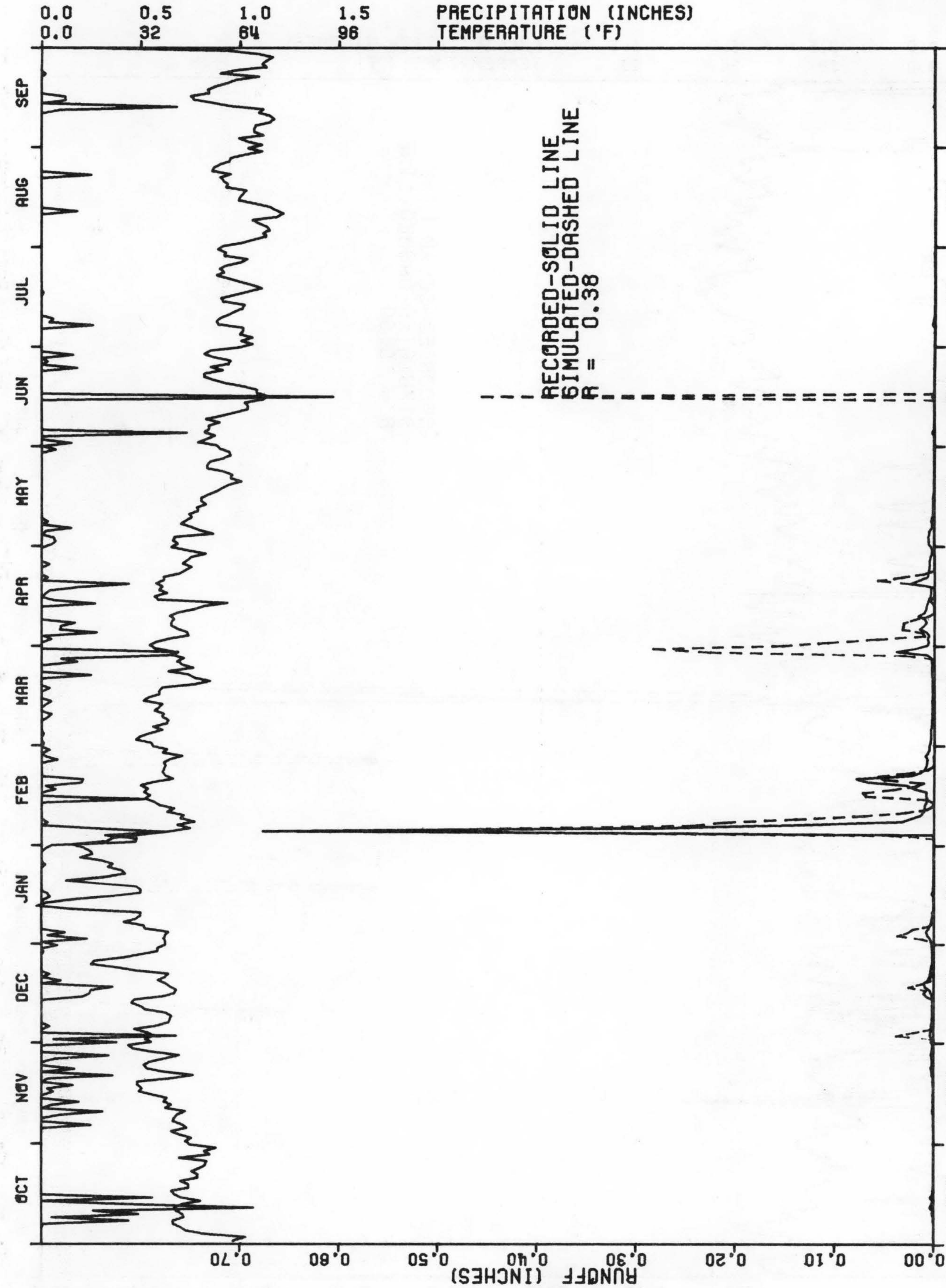

Figure 19. Precipitation, daily mean temperature and daily comparison of observed and simulated runoff (Missouri Flat Creek watershed in 1963)

ing. By delaying this runoff, the later peaks and volumes would be boosted.

2. The simulation of the 1962 water year (Figure 18) is another good example of the significant effect which snowmelt has on runoff. The peaks during December March might result from snowmelt. This can be seen in Table 13. However, another possible cause of this poor simulation is snow drifting and sublimation which reduce available amounts of snow on the ground before any melt event. Those peaks occur during periods of high soil moisture generated by high snowmelt. This fast melt may be a reason for the rapid recession over the next days. The peak of day 176 is well simulated showing that the rainfall-runoff portion of the model works well when there is a fair amount of soil moisture.

3. The results for the 1963 water year show an acceptable simulation except for the two high peaks in March and June. The first peak took place during four days of high rainfall after a month of low precipitation. The soil moisture should have been dry enough to retain the moisture input; but the simulated soil moisture was too high. The second peak was caused by high runoff, mostly overland flow, during three hours of the day. The precipitation recorded at Pullman shows 1.47 inches of rain for the day with a maximum intensity of 1.35 inches per hour. No other rain gages near the station recorded this high rainfall. This may be a recording mistake or may have been a highly concentrated storm at the station. This has not yet been verified. A high recorded runoff on days 126 and 127 shows a good example of frozen ground effects after a long cold period.

Overland Flow

The subroutine PEROUT routes moisture input in excess of infiltration and ET across each soil zone and cascades, subject to further infiltration and ET, across designated subsequent soil zones on route to the channel. The base routing equation is a function of soil cover, slope and overland flow length. The detailed theory used in this model is explained by Holtan and others (1975).

The model has an output option of the overland flow hydrograph. Appendix 3 shows the actual output for an event on Thompson Watershed. The output includes rate and depth of overland flow as well as the amount of water infiltrated into the soil. Appendices 4, 5 and 6 show the monthly results of overland flow for each zone for the tested watersheds. The simulated values appear to be low on the upper zones and high on the alluvium for Pitzen and Missouri Flat Creek watersheds which are divided into three zones each. Thompson watershed values appear more reasonable, but this is not to say that the former two watersheds were more poorly simulated than the latter since no observed values are available.

As mentioned in the chapter REVISION OF USDAHL WATERSHED MODEL, there are three small plots installed near Pullman. The runoff samples from the plots could be assumed to be overland flow or a combination of overland flow and rill flow. Using these data it would be possible to test the simulated overland flow and to evaluate the reliability of the model's overland flow routing procedures.

Frozen Ground Effect

Many times rainfall and snowmelt occur under frozen ground conditions. This situation causes high surface runoff which results in accelerated upland erosion. Since this condition is so important, a dependable method must be found that will simulate frozen ground events in the USDAHL-74 model. McCool and Molnau (1974) and Yen (1975) studied the freezing index as a parameter to predict frozen soil in the Palouse. They concluded that the freezing index and precipitation combinations can be used, with some discretion, in the prediction of frozen soil runoff events. Yen (1975) used multivariate analysis to determine frozen ground conditions. He inserted eight discriminators for his study and found that the freezing index was the most significant factor for estimating the probability of frozen ground.

A frozen ground event was defined with an index temperature in the SUBSUR subroutine. When the average temperature for seven previous days is less than the index temperature (DXFGR) lateral flow in layer 1 is reduced as a function of degrees below the index temperature. If the average temperature is below 20°F, the moisture movement is stopped. The model does not change the infiltration rate to layer 1 under frozen ground conditions. This may not be reasonable in the Palouse area since runoff occurring during a frozen ground event usually takes place as overland flow.

Two high runoff events observed from Thompson watershed in 1972 and one from Missouri Flat Creek in 1963 are thought to be caused by the joint effect of snowmelt and rainfall on frozen ground. These are shown in Figures 11 and 19. They occurred in mid February on Thompson and in early February in Missouri Flat Creek. All of these peaks took place after long cold days of below freezing temperature. The index temperature used in this study was 25°F. The low peaks simulated for the periods might be caused by the method of dealing with frozen ground events in the model but this will have to await further investigation.

USDAHL-74 AND EROSION MODELLING

Introduction

The Palouse basin of the Pacific Northwest is one of the highest grain producing areas of the nation. Unfortunately, it is also known as one of the most severely eroded areas (McCool and Johnson, 1973; Horner and others, 1944). This has two consequences. One is the loss of the fertile top soil and nutrients from the field. The other is the pollution of the basins's streams, which empty into the Columbia River. Most of the erosion occurs during December through March.

There are several causative factors for this erosion. They are:

1. Rainfall and/or snowmelt on frozen ground or on bare fields.

2. High soil moisture content and consequent runoff.

3. No field protection except some plant residue.

4. Steep slopes.

5. Long slope lengths.

6. Disturbed soil after fall tillage.

The soil erosion problems in the Palouse have been studied for a long time. The first study was started when the USDA built an erosion laboratory at the Soil and Water Conservation Experiment Station near Pullman, Washington in the early 1930s (Horner and McGrew, 1935). This was one of several soil erosion laboratories built throughout the nation. Several reports and publications are available from the experiment station. They include a great deal of valuable climatological and hydrological data as well as erosion data for the streams in the basin.

In the 1960's, the ARS and the Agricultural Engineering Department of the University of Idaho operated Thompson watershed near Moscow, Idaho as an experimental watershed. This area was intensively studied in 1970, 1971 and 1972 water years. Data are available for runoff, precipitation, snow, frozen ground and sediment concentration.

Erosion Modeling

The primary purpose of this section of this report is to suggest methods of coupling the watershed model with an erosion model which is being developed by the authors.

The erosion model will be basically a deterministic mathematical model. The model will simulate the temporal and spatial distribution of erosion responding to the variability of overland flow, snowmelt and rainfall, ET, development of rills and gullies, degree of slope, tillage practice, soil moisture and soil types. These variables have been shown to be important factors in erosion and deposition of soil on a field (Musgrave, 1947; Smith and Wischmeier, 1957; Ellison, 1952; Meyer and Monke, 1965).

A two dimension erosion plane of time and distance will be used to calculate soil movement at a point. The soil erosion process as developed by Meyer and Wischmeier (1969) will be the basis of simulation. Erosion or deposition at a point are structured by considering the variables which affect soil particle movement. The partition time, DELT, is the main repetition factor for water movement simulation. This delta time system will be used as one axis of the erosion plane.

The other axis of the plane is the distance from an initial point, usually the uppermost point of a field, to the channel. The watershed model uses a maximum of four zones to define different field characteristics and to cascade downward movement of water from high elevation areas to the alluvium and channel. This method of dividing a field would be useful but not sufficient for the erosion model, which may need more grid points on the erosion plane. It is desirable to divide a zone into several subzones considering the degree of slope, length of overland flow, and rill and gully distribution.

Most of the information required for an erosion model is available from USDAHL-74. Overland flow is the most important factor among them (Foster and Meyer, 1972; Podmore and Merva, 1969; Meyer and Monke, 1965; Li and others, 1973). The kinetic energy of flowing water is used to detach and transport the soil particles as runoff passes down to lower land. A part of the kinetic energy of the rain is added to the overland flow as the raindrops strike the flowing sheet of water and increase its turbulence. However, if the potential energy is reduced below the level necessary to keep the soil particles in suspension, deposition starts to take place. The kinetic energy of overland flow depends mainly on the amount, depth and velocity of the flowing water and the soil surface conditions.

Therefore, it is necessary to simulate the depth as well as the rate of overland flow. These are calculated and printed by the watershed model. However, there are not any observed overland flows or near-overland flows with which the calculated values can be compared. To solve this problem, the runoff from the small plots near Pullman, Washington could be considered as overland flow or at least sheet flow. Data collection is proceeding on these plots.

Several researchers have emphasized the role played by raindrop impact in the process of soil erosion (Bubenzer and Jones, 1971; Ellison, 1952; Meyer and Monke, 1965; Ekern, 1950). They found that the kinetic energy of raindrop impact mainly depends on rainfall rate, drop size, impact velocity and duration of rainfall. Not all of these variables are directly available. However, a strong relationship exists among them (Ekern, 1950; Bubenzer and Jones, 1971). Wischmeier and Smith (1958) developed a regression equation describing rainfall energy as a function of rainfall intensity and found that the product of total rainfall energy of a storm and its maximum 30 minute intensity is the best single variable for predicting soil loss from cultivated fallow plots of fraction-acre size when factors other than rainfall are constant. Ellison (1952) stated that water applied as raindrops was more effective in soil detachment and setting the particles in motion than was overland flow alone (Meyer and Monke, 1965).

Rill erosion is one of the biggest and most obvious sources of soil loss in the Palouse. Figure 20 shows the formation of rills in the Palouse area. Rill erosion is defined (Smith and Wischmeier, 1957) as "removal of soil by running water with formation of shallow channels that can be smoothed out completely by cultivation.

Kilinc (1972) enalyzed all possible relationships of several variables related to sheet erosion. He found that the rate of rill erosion depends on rainfall intensity, degree of slope, soil properties and surface conditions (roughness, vegetation and tillage). He also established regression equations predicting the ratio of rill area to surface area, average depth of rill and ratio of rill volume to total erosion volume. These equations are not directly usable in the Palouse area but may be usable with some modification.

Channel flow causes significant soil erosion also. It scours sediments from the channel bottom and banks and delivers them to the lower stream as well as picking up the entering soil particles eroded from upland. Dragoun (1962) found the best single factor predicting sediment from cultivated land is the sum of the volume of runoff in inches and peak rate of runoff in inches per hour. There is, of course, the deposition of suspended and bedload materials when the transportation capacity of the channel flow decreases to a point below the supply of available eroded soil particles. Some minor bank slumps are also a source of sediments. These events are not significant compared to the erosion from the upland areas. However, they should not be excluded in any sediment yield model which would simulate sediment movement to downstream areas in a watershed.

These four factors discussed above (overland flow, raindrop impact, channel flow and rill flow) are the most direct and important agents in causing soil erosion in an agricultural watershed. Other variables mentioned before such as slope, crop cover, soil moisture, etc. are also important and related to the former factors. The information to be obtained from the watershed model is:

1. Depth, rate and amount of overland flow.

2. Hydrograph of channel flow.

3. The rate of moisture input (rainfall and snowmelt--the intensity of rainfall could also be obtained).

4. Lateral flow from the subsurface--the lateral flow from the shallow part of the top layer may contribute to rill flow.

Figure 20. Rill formation on Palouse hillside

These are all available on a time break basis. The following are obtained on a daily or weekly scale:

5. Soil moisture content.

6. Evapotranspiration and direct evaporation from soil.

7. Tillage practices.

8. Crop growing index curves.

These simulated data will be checked against any observed data to ensure the predicted soil erosion will be as free as possible from the error terms created by the watershed model. This may require the replacement of the simulated values with the observed when the erosion model is being developed.

SUMMARY AND CONCLUSIONS

The USDAHL-74 watershed model was applied to three different sized watersheds in the Palouse basin of Washington and Idaho. The watersheds are located around the Moscow-Pullman area. Basically, they have similar hydrologic conditions. Therefore, some of the required input parameters for the model were common to all three watersheds. For the first simulation for each watershed, the input parameters were estimated using the procedures of Holtan and others (1975). These parameters were then modified as required to improve the simulated daily runoff.

The original model was changed in several respects. The most important of these changes were:

1. Daily maximum and minimum temperatures were substituted for the mean weekly temperatures. The temperature at various times during the day is calculated assuming a sinusoidal temperature variation.

2. Moisture movement procedure from the A to B horizon was changed so that most of the moisture capacity of the lower layers are satisfied before lateral flow takes place in the upper layer.

3. The snowmelt portion of the model was placed into a separate subroutine to facilitate later changes. A new snowmelt subroutine is being developed under a parallel project in the Idaho Agricultural Experiment Station (King, 1976).

4. Numerous changes in program logic and coding were also made and documented as an inpublished report of the Agricultural Engineering Department.

5. The program now operates on a water year basis starting 1 October rather than on a calendar year basis.

Based on the results of this study, the following conclusions can be drawn:

1. The water year based simulation is very useful in obtaining the entire runoff season in one simulation and in defining the required initial parameters.

2. The free water separation revision improved the simulation during and after a long dry season. This is not completely satisfactory, however, since there were some poor simulations when the soil was wet before a rainfall.

3. The routing coefficients of the first and the second layers as calculated in the PARAMS subroutine seem to poorly estimate the time of storage.

4. The winter pan evaporation data needs to be improved. The method used in this report was the most direct available but does not appear to be proper during February and March. This controls the soil moisture and therefore the available water holding capacity which is probably the single most important factor in simulation.

5. Seasonal variation of groundwater recharge and infiltration rates are needed for a better simulation. Some of the higher predicted runoff in the warm season was caused by high overland flow possibly because of the low infiltration rate used in this study. If both infiltration and groundwater recharge were allowed to vary with season or with temperature, the simulation probably could be improved.

6. The snowmelt routine is inadequate. The other changes in the program cannot overcome the basic inability of the present equation to represent melt.

7. The model gives valuable information about overland flow. It gives depth and rate of overland flow. However, the results do not always seem to be reasonable, especially when a watershed is divided into more than two zones. Most overland flow occurs on alluvium and little or none on upper zones even when there is significant rainfall. A reasonable simulation was obtained on the Thompson watershed which consisted of only one zone.

8. Frozen ground effect on runoff does not seem to be properly simulated. The model uses antecedent temperature, but the freezing index used by McCool and Molnau (1974) coupled with antecedent moisture (Bloomsburg and Wang, 1969) may be better for determining frozen ground conditions.

9. Subroutine POLLUT includes most of the parameters necessary for erosion modelling. Should any others prove necessary, it would be very easy to add them to that subroutine.

It is felt that this model does form a viable basis for any type of erosion model. With the inclusion of the new snowmelt routine being developed under a parallel Idaho Agricultural Experiment Station, the weakest point of the model will be greatly improved.

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APPENDIX I

ESTIMATING WINTER PAN EVAPORATION

Winter pan evaporation (November-April) has to be estimated using data from the U.S. Department of Commerce's "Climatic Atlas of the United States" since such evaporation information is not available.

Total annual mean pan evaporation 45 inches (based on period 1947-55).

Mean May-October evaporation is 81 percent of the annual amounts. Then

45 x .81 = 36.45 inches (May-October). 45-36.45 = 8.55 inches is the November-April evaporation.

Month*	Distribution**	Per Month (inches)	Average Per Day
Nov.	15%	1.26	0.042
Dec.	6%	0.505	0.016
Jan.	6%	0.505	0.016
Feb.	9%	0.758	0.027
Mar.	24%	2.02	0.065
Apr.	40%	3.5	0.113

* Daily pan evaporation data for other moths are usually available from National Weather Service publications

** The percentage distribution was estimated from temperature data except for April which is from record, later optimized

APPENDIX II

ESTIMATING SOIL MOISTURE PARAMETERS - THOMPSON WATERSHED

This appendix presents the method used for estimating soil moisture parameters for the Thompson Watershed. The values for the other two watersheds are calculated similarly.

5.2 inches/ft at 1/3 atmosphere

2/3 inches/ft at 15 atmosphere

S = total porosity - 15 atmosphere moisture percentage

G = total porosity - 1/3 atmosphere percentage

Available Water (AWC) - S-G

Total porosity is estimated about 55% for the A horizon and approximately 50% for the B horizon.

1/3 atmosphere moisture percent - 43.3%

15 atmosphere moisture percent - 19%

For the A horizon:

G = 55 - 43.3 = 11.7%

S = 55 - 19.1 = 35.9%

AWC = 35.9 - 11.7 = 24.2%

For the B horizon:

G = 50 - 43.3 = 6.7

S = 50 - 19.1 - 30.9

AWC = 30.9 - 6.7 = 24.2

[illegible]

[illegible] SOIL MOISTURE [illegible] - [illegible]

[illegible] the [illegible] moisture [illegible] horizons [illegible] the [illegible] for the [illegible] are [illegible]

[illegible]

[illegible]

[illegible]

[illegible] total porosity [illegible]

Available Water (AW%) = [illegible]

Total porosity is estimating about [illegible] for the A horizon and about [illegible] for the B horizon.

(1) Available moisture percentage [illegible]

[illegible]

For the A horizon:

[illegible]

[illegible]

[illegible]

For the B horizon:

[illegible]

[illegible]

[illegible]

APPENDIX III

SAMPLE OUTPUT OF OVERLAND FLOW HYDROGRAPH

OVERLAND FLOW HYDROGRAPH FOR YEAR 1939 DAY 162

TIME	RAINT	QO Z1	D1 Z1	SF Z1	QO Z2	D1 Z2	SF Z2	QO Z3	D1 Z3	SF Z3
1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00825
2.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01646
3.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02463
3.250	0.0400	0.0	0.0	0.01000	0.0	0.0	0.01000	0.0	0.0	0.03667
3.350	0.0	0.0	0.0	0.01000	0.0	0.0	0.01000	0.0	0.0	0.03749
3.650	0.0	0.0	0.0	0.01000	0.0	0.0	0.01000	0.0	0.0	0.03993
4.000	0.0	0.0	0.0	0.01000	0.0	0.0	0.01000	0.0	0.0	0.04278
4.500	0.0400	0.0	0.0	0.03000	0.0	0.0	0.03000	0.0	0.0	0.06684
5.000	0.0400	0.0	0.0	0.05000	0.0	0.0	0.05000	0.0	0.0	0.09089
5.500	0.0700	0.0	0.0	0.08500	0.0	0.0	0.08500	0.0	0.0	0.13418
6.000	0.0700	0.0	0.0	0.12000	0.0	0.0	0.12000	0.0	0.0	0.19268
6.375	0.0400	0.0	0.0	0.13500	0.0	0.0	0.13500	0.0	0.0	0.23906
6.750	0.0400	0.0	0.0	0.15000	0.0	0.0	0.15000	0.0	0.0	0.28943
6.850	0.0	0.0	0.0	0.15000	0.0	0.0	0.15000	0.0	0.0	0.30253
7.000	0.0	0.0	0.0	0.15000	0.0	0.0	0.15000	0.0	0.0	0.31659
7.500	0.0400	0.0	0.0	0.17000	0.0	0.0	0.17000	0.0	0.0	0.38122
8.000	0.0400	0.0	0.0	0.19000	0.0	0.0	0.19000	0.0	0.0	0.45236
8.100	0.0	0.0	0.0	0.19000	0.0	0.0	0.19000	0.0	0.0	0.46989
8.400	0.0	0.0	0.0	0.19000	0.0	0.0	0.19000	0.0	0.0	0.50580
9.000	0.0	0.0	0.0	0.19000	0.0	0.0	0.19000	0.0	0.0	0.57521
9.500	0.0400	0.0	0.0	0.21000	0.0	0.0	0.21000	0.0	0.0	0.65041
9.600	0.0	0.0	0.0	0.21000	0.0	0.0	0.21000	0.0	0.0	0.66765
9.900	0.0	0.0	0.0	0.21000	0.0	0.0	0.21000	0.0	0.0	0.70546
10.000	0.0	0.0	0.0	0.21000	0.0	0.0	0.21000	0.0	0.0	0.71773
10.500	0.0700	0.0	0.0	0.24500	0.0	0.0	0.24500	0.0	0.0	0.80457
11.000	0.0700	0.0	0.0	0.28000	0.0	0.0	0.28000	0.0	0.0	0.88641
11.500	0.0600	0.0	0.0	0.31000	0.0	0.0	0.31000	0.06171	0.01191	0.96825
12.000	0.0600	0.0	0.0	0.34000	0.0	0.0	0.34000	0.16577	0.02153	1.05009
12.100	0.0	0.0	0.0	0.34000	0.0	0.0	0.34000	0.26957	0.02881	1.06346
12.400	0.0	0.0	0.0	0.34000	0.0	0.0	0.34000	0.0	0.0	1.11357
13.000	0.0	0.0	0.0	0.34000	0.0	0.0	0.34000	0.07792	0.01370	1.21377
13.500	0.0700	0.0	0.0	0.37500	0.0	0.0	0.37500	0.16087	0.02115	1.29562
14.000	0.0700	0.0	0.0	0.41000	0.0	0.0	0.41000	0.15407	0.02061	1.37746
14.500	0.0700	0.0	0.0	0.44500	0.0	0.0	0.44500	0.19352	0.02362	1.45930
15.000	0.0700	0.0	0.0	0.48000	0.0	0.0	0.48000	0.23133	0.02629	1.54114
15.500	0.0700	0.0	0.0	0.51500	0.0	0.0	0.51500	0.24059	0.02691	1.62298
16.000	0.0700	0.0	0.0	0.55000	0.0	0.0	0.55000	0.25000	0.02754	1.70482
16.500	0.0700	0.0	0.0	0.58500	0.0	0.0	0.58500	0.27013	0.02884	1.78666
17.000	0.0700	0.0	0.0	0.62000	0.0	0.0	0.62000	0.33489	0.03280	1.86850
17.500	0.0700	0.0	0.0	0.65500	0.0	0.0	0.65500	0.26088	0.02825	1.95034
18.000	0.0700	0.0	0.0	0.69000	0.0	0.0	0.69000	0.37007	0.03483	2.03218
18.500	0.0700	0.0	0.0	0.72500	0.0	0.0	0.72500	0.36899	0.03477	2.11402
19.000	0.0700	0.0	0.0	0.76000	0.0	0.0	0.76000	0.37800	0.03527	2.19586
19.500	0.0700	0.0	0.0	0.79500	0.0	0.0	0.79500	0.40652	0.03684	2.27770
20.000	0.0700	0.0	0.0	0.83000	0.0	0.0	0.83000	0.45886	0.03961	2.35954
20.500	0.0700	0.0	0.0	0.86500	0.0	0.0	0.86500	0.42350	0.03776	2.44138
21.000	0.0700	0.0	0.0	0.90000	0.0	0.0	0.90000	0.42499	0.03784	2.52322
21.500	0.0700	0.0	0.0	0.93500	0.0	0.0	0.93500	0.49627	0.04152	2.60506
22.000	0.0700	0.0	0.0	0.97000	0.0	0.0	0.97000	0.49391	0.04140	2.68690
22.500	0.0700	0.0	0.0	1.00500	0.0	0.0	1.00500	0.52758	0.04307	2.76874
23.000	0.0700	0.0	0.0	1.04000	0.0	0.0	1.04000	0.50900	0.04215	2.85058
23.500	0.0	0.0	0.0	1.04000	0.0	0.0	1.04000	0.39700	0.03632	2.93243
24.000	0.0	0.0	0.0	1.04000	0.0	0.0	1.04000	0.47551	0.04047	3.01427

OVERLAND FLOW HYDROGRAPH FOR YEAR 1939 DAY 163

TIME	RAINT	QO Z1	D1 Z1	SF Z1	QO Z2	D1 Z2	SF Z2	QO Z3	D1 Z3	SF Z3
0.500	0.3026	0.04990	0.02593	0.06536	0.02941	0.03383	0.06537	1.09606	0.06672	0.08184
1.000	0.0	0.0	0.0	0.13068	0.0	0.0	0.13024	0.16279	0.02130	0.16368
1.500	0.0	0.0	0.0	0.13899	0.0	0.0	0.14689	1.01065	0.06356	0.24552
2.000	0.0	0.0	0.0	0.13899	0.0	0.0	0.14689	0.0	0.0	0.32736
2.500	0.0	0.0	0.0	0.13899	0.0	0.0	0.14689	0.71654	0.05173	0.40920
3.000	0.0	0.0	0.0	0.13899	0.0	0.0	0.14689	0.42780	0.03798	0.49104
3.500	0.0	0.0	0.0	0.13899	0.0	0.0	0.14689	0.49872	0.04164	0.57288
3.600	0.0	0.0	0.0	0.13899	0.0	0.0	0.14689	0.41513	0.03731	0.58625
3.900	0.0	0.0	0.0	0.13899	0.0	0.0	0.14689	0.38747	0.03580	0.63636
4.500	0.0	0.0	0.0	0.13899	0.0	0.0	0.14689	0.39959	0.03646	0.73657
5.500	0.0	0.0	0.0	0.13899	0.0	0.0	0.14689	0.42562	0.03787	0.90025
6.500	0.0	0.0	0.0	0.13899	0.0	0.0	0.14689	0.45746	0.03954	1.05893
7.500	0.0008	0.0	0.0	0.13978	0.0	0.0	0.14768	0.35528	0.03399	1.21761
8.500	0.0106	0.0	0.0	0.15043	0.0	0.0	0.15833	0.45352	0.03934	1.37629
9.500	0.0218	0.0	0.0	0.17230	0.0	0.0	0.18021	0.35026	0.03370	1.53497
10.500	0.0331	0.0	0.0	0.20540	0.0	0.0	0.21330	0.50402	0.04190	1.69365
11.500	0.0429	0.0	0.0	0.24837	0.0	0.0	0.25627	0.34911	0.03363	1.85233
12.500	0.0502	0.0	0.0	0.29866	0.0	0.0	0.30656	0.57458	0.04532	2.01101
13.000	0.0526	0.0	0.0	0.32501	0.0	0.0	0.33291	0.42418	0.03779	2.09285
13.500	0.2041	0.0	0.0	0.39032	0.0	0.0	0.39823	0.86555	0.05793	2.17469
14.000	0.2046	0.02628	0.01766	0.45563	0.01729	0.02461	0.46304	0.56022	0.04464	2.25653
14.500	0.1870	0.05631	0.02788	0.52095	0.04336	0.04269	0.52755	1.56336	0.08253	2.33838
15.000	0.0500	0.0	0.0	0.58626	0.0	0.0	0.59180	0.38607	0.03572	2.42022
15.500	0.0500	0.0	0.0	0.64652	0.0	0.0	0.65578	0.89938	0.05927	2.50206
16.000	0.0500	0.0	0.0	0.67152	0.0	0.0	0.68950	0.30734	0.03116	2.58390
16.100	0.0	0.0	0.0	0.67152	0.0	0.0	0.68950	0.87309	0.05823	2.59726
16.400	0.0	0.0	0.0	0.67152	0.0	0.0	0.68950	0.90890	0.05965	2.64737
17.000	0.0	0.0	0.0	0.67152	0.0	0.0	0.68950	0.50845	0.04212	2.74758
18.000	0.0	0.0	0.0	0.67152	0.0	0.0	0.68950	0.57700	0.04544	2.91126
19.000	0.0	0.0	0.0	0.67152	0.0	0.0	0.68950	0.47903	0.04065	3.06994
20.000	0.0	0.0	0.0	0.67152	0.0	0.0	0.68950	0.60115	0.04657	3.22862
21.000	0.0	0.0	0.0	0.67152	0.0	0.0	0.68950	0.42046	0.03759	3.38730
22.000	0.0	0.0	0.0	0.67152	0.0	0.0	0.68950	0.62817	0.04781	3.54598
23.000	0.0	0.0	0.0	0.67152	0.0	0.0	0.68950	0.37418	0.03506	3.70466
24.000	0.0	0.0	0.0	0.67152	0.0	0.0	0.68950	0.58792	0.04595	3.86334

APPENDIX IV

INPUT PARAMETERS AND SUMMARY TABLE

FOR THOMPSON WATERSHED

USDAHL '74 MODEL OF WATERSHED HYDROLOGY

INDEX TEMPERATURE TO CONTROL THE CRITICAL VALUES

SNOW	FREEZING	MELT	ET	TIME OF MAX TEMP	TIME OF MIN TEMP
34.00	25.00	34.00	28.00	14.00	5.00

USDAHL '74 MODEL OF WATERSHED HYDROLOGY
THOMPSON WATERSHED, MOSCOW, IDAHO, 1971 WATER YEAR

STORM HYDROGRAPHS WILL BE PRINTED FOR THE FOLLOWING DATES:

MO	DAY	(JULIAN)	YR	MO	DAY	(JULIAN)	YR	MO	DAY	(JULIAN)	YR	MO	DAY	(JULIAN)	YR
1	8	100	71	1	9	101	71	1	16	108	71	1	17	109	71
1	18	110	71	1	19	111	71	1	20	112	71	1	21	113	71
1	22	114	71	2	10	133	71	2	11	134	71	2	12	135	71
2	13	136	71	2	24	147	71	2	25	148	71	2	26	149	71
6	1	244	71	6	2	245	71	6	3	246	71	6	4	247	71
6	13	256	71	6	14	257	71	6	15	258	71	6	16	259	71

WATERSHED PARAMETERS

ACRES= 8.2 NUMBER OF ZONES= 1.0 RTG COEFF: TOTAL= 5.0 ABOVE WEIR= 5.0 NUMBER OF CROPS= 1.0

DEEP GROUND WATER RECHARGE= 0.00050 DOES LAND USE CHANGE? YES DOES YEARLY TILLAGE CHANGE? YES

GENERAL ZONE PARAMETERS

ZONE	% W/S	LENGTH	SLOPE	FC	DPTH TOP	AERATED DPTH
1	100.0	180.	15.50	0.080	9.0	60.0

SOIL PARAMETERS

ZONE	% G1	% AWC1	% ASM1	% CRAK1	% G2	% AWC2	% ASM2	% CRAK2
1	11.7	24.2	10.0	0.0	6.7	24.2	17.1	0.0

ROUTING PARAMETERS

CHANNEL ROUTING DELT T= 1.000 CHANNEL COEFFICIENT= 0.26 INITIAL STREAM FLO= 0.0 INITIAL SNOW COVER= 0.0

SUBSURFACE PARAMS

REGIME	Q-MAX	COEFFICIENT
1	0.03870	1.20
2	0.01260	5.60
3	0.00440	32.60
4	0.00100	150.00

COEFFICIENTS AND MAXIMUM Q'S PROPORTIONED TO ZONES ACCORDING TO TOPSOIL DEPTH

REGIME	M Z1	Q Z1
1	2.56	0.411951
2	25.29	0.135090
3	32.60	0.004400
4	150.00	0.001000

THE SOIL PARAMETERS IN INCHES FOLLOW.

ZONE	LAYER	G	AWC	SA	CRACKING	C(IN/HR)	TOPD	SOILD
1	1	1.053	2.178	2.331	0.0	0.1356	9.00	60.00
	2	3.417	12.342	7.047	0.0	0.0049		
	3	0.143	0.0	0.143	0.0	0.0015		
	4	0.150	0.0	0.150	0.0	0.0005		

LAND USE PARAMETERS

	SPBARLEY
A VALUES	0.30
CROP VD	0.05
ETEP	1.40
ROOT DEPTH	24.00
UPPER TEMP	90.00
LOWER TEMP	35.00

TILLAGE WILL BE READ YEARLY.

CROP	% GRAZING	TILLAGE PRACTICES							
SPBARLEY	0	PLO	42071	PLA	5 171	HAR	81571	PLO	82071

GI CURVES

WEEK	TEMP	SPBARLEY
1	51.71	0.30
2	43.86	0.30
3	49.07	0.30
4	37.07	0.30
5	44.36	0.30
6	39.00	0.30
7	38.57	0.30
8	28.79	0.30
9	30.36	0.30
10	33.14	0.30
11	27.86	0.30
12	19.43	0.30
13	27.14	0.30
14	16.50	0.30
15	29.36	0.30
16	35.00	0.30
17	35.36	0.30
18	40.57	0.30
19	26.86	0.30
20	41.00	0.30
21	32.93	0.30
22	24.57	0.30
23	30.71	0.30
24	30.14	0.30
25	35.93	0.30
26	37.93	0.30
27	43.43	0.30
28	41.93	0.30
29	40.71	1.00
30	41.79	0.75
31	54.36	0.10
32	60.00	0.14
33	44.86	0.18
34	54.64	0.25
35	51.14	0.27
36	53.79	0.32
37	55.07	0.35
38	61.29	0.46
39	53.00	0.33
40	55.50	0.37
41	60.71	0.47
42	74.29	0.71
43	73.21	0.69
44	75.29	0.73
45	76.21	0.75
46	68.93	0.19
47	63.43	1.00
48	66.21	0.75
49	56.00	0.10
50	53.50	0.10
51	51.79	0.10
52	51.07	0.10

LAND USE FOR YEAR 1971 FOLLOWS. IF A ZONE IS NOT MENTIONED, VALUES OF PREVIOUS YEAR ARE ASSUMED.

ZONE 1 SPBARLEY=100.0%

PAN EVAPORATION FOR YEAR 1971 FOLLOWS.

WEEK 1	0.114	0.097	0.080	0.063
WEEK 5	0.042	0.042	0.042	0.042
WEEK 9	0.042	0.016	0.016	0.016
WEEK 13	0.016	0.016	0.016	0.016
WEEK 17	0.016	0.027	0.027	0.027
WEEK 21	0.027	0.065	0.065	0.065
WEEK 25	0.065	0.065	0.147	0.090
WEEK 29	0.135	0.166	0.183	0.183
WEEK 33	0.213	0.166	0.126	0.101
WEEK 37	0.112	0.164	0.114	0.209
WEEK 41	0.196	0.260	0.289	0.269
WEEK 45	0.273	0.271	0.223	0.213
WEEK 49	0.117	0.226	0.207	0.154

THE FOLLOWING IS A MONTHLY SUMMARY OF WATER YIELDS 1971:

MONTH	RAIN+ MELT	ET	EVAP	RUNOFF	RETURN FLOW ONSITE	RETURN FLOW OFFSITE	GR
1	1.480	0.467	0.001	0.0	0.0	0.0	0.0
2	2.157	0.422	0.004	0.140	0.043	0.0	0.0
3	1.321	0.106	0.000	0.010	0.010	0.0	0.0
4	3.681	0.152	0.003	2.255	1.653	0.0	0.198
5	1.640	0.247	0.003	1.159	1.121	0.0	0.241
6	1.760	0.653	0.007	0.947	0.930	0.0	0.257
7	1.150	2.986	0.0	0.001	0.001	0.0	0.010
8	1.750	1.211	0.013	0.011	0.000	0.0	0.0
9	3.650	1.891	0.037	0.900	0.853	0.0	0.209
10	0.650	4.330	0.002	0.0	0.0	0.0	0.0
11	1.130	1.565	0.0	0.0	0.0	0.0	0.0
12	1.580	0.375	0.020	0.0	0.0	0.0	0.0
TOTAL	21.950	14.405	0.091	5.424	4.611	0.0	0.915

ZONE 1

RETURN FLOW

MO	QO	ONSITE	OFFSITE	GR
1	0.0	0.0	0.0	0.0
2	0.10	0.04	0.0	0.0
3	0.0	0.01	0.0	0.0
4	0.60	1.65	0.0	0.20
5	0.04	1.12	0.0	0.24
6	0.02	0.93	0.0	0.26
7	0.0	0.00	0.0	0.01
8	0.01	0.00	0.0	0.0
9	0.05	0.85	0.0	0.21
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
TOTAL	0.81	4.61	0.0	0.91

THE FOLLOWING ARE SA VALUES IN INCHES AT THE TIME THE ABOVE SUMMARY WAS PRINTED:
ZONE= 1 1.2105 7.0470 0.1434 0.1500

THE FOLLOWING ARE RE-START VALUES TO APPROXIMATE WATERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

INITIAL STREAM FLO= 0.0

ZONE	% ASM1	% ASM2
1	22.450	17.082

RAIN-ET-RUNOFF-E-CN-SOIL-CHANNEL-DEPRESSIONS-OVERLAND-OFFSITE= -0.006
21.950 14.405 5.424 0.091 0.915 1.121 0.0 0.0 0.0 0.0

SNOW= 0.0

STATISTICS

SUM OF OBSERVED = 0.61299734E 01 SUM OF SQUARE OF OBSERVED = 0.15098772E 01
SUM OF PREDICTED = 0.54237509E 01 SUM OF SQUARE OF PREDICTED = 0.10884809E 01
MEAN OF OBSERVED = 0.16748559E-01 MEAN OF PREDICTED = 0.14818989E-01

CORRELATION COEFFICIENT = 0.45375615E 00
STANDARD DEVIATION = 0.55255778E-01
COVARIANCE = 0.32991362E 01

LAND USE FOR YEAR 1972 FOLLOWS. IF A ZONE IS NOT MENTIONED, VALUES OF PREVIOUS YEAR ARE ASSUMED.

ZONE 1 SPBARLEY=100.0%

PAN EVAPORATION FOR YEAR 1972 FOLLOWS.

WEEK 1	0.114	0.097	0.080	0.063
WEEK 5	0.042	0.042	0.042	0.042
WEEK 9	0.042	0.016	0.016	0.016
WEEK 13	0.016	0.016	0.016	0.016
WEEK 17	0.016	0.027	0.027	0.027
WEEK 21	0.027	0.065	0.065	0.065
WEEK 25	0.065	0.065	0.147	0.090
WEEK 29	0.135	0.163	0.177	0.217
WEEK 33	0.210	0.194	0.301	0.188
WEEK 37	0.146	0.178	0.210	0.294
WEEK 41	0.217	0.154	0.287	0.326
WEEK 45	0.339	0.216	0.226	0.326
WEEK 49	0.245	0.190	0.166	0.127

THE FOLLOWING IS A MONTHLY SUMMARY OF WATER YIELDS 1972:

MONTH	RAIN+ MELT	ET	EVAP	RUNOFF	RETURN FLOW ONSITE	RETURN FLOW OFFSITE	GR
1	1.080	0.814	0.000	0.002	0.002	0.0	0.0
2	2.860	0.486	0.001	0.051	0.051	0.0	0.0
3	3.418	0.129	0.004	1.865	1.505	0.0	0.174
4	3.905	0.090	0.004	3.476	3.073	0.0	0.369
5	3.107	0.351	0.004	2.399	2.274	0.0	0.288
6	4.060	0.803	0.015	3.155	3.103	0.0	0.372
7	0.990	2.850	0.000	0.011	0.011	0.0	0.000
8	2.380	1.989	0.022	0.110	0.004	0.0	0.0
9	0.430	2.267	0.0	0.0	0.0	0.0	0.0
10	0.830	2.216	0.0	0.0	0.0	0.0	0.0
11	0.600	0.791	0.0	0.0	0.0	0.0	0.0
12	0.700	0.096	0.0	0.0	0.0	0.0	0.0
TOTAL	24.360	12.880	0.049	11.070	10.025	0.0	1.204

ZONE 1

RETURN FLOW

MO	QO	ONSITE	OFFSITE	GR
1	0.0	0.00	0.0	0.0
2	0.0	0.05	0.0	0.0
3	0.36	1.51	0.0	0.17
4	0.40	3.07	0.0	0.37
5	0.12	2.27	0.0	0.29
6	0.05	3.10	0.0	0.37
7	0.0	0.01	0.0	0.00
8	0.11	0.00	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
TOTAL	1.04	10.02	0.0	1.20

THE FOLLOWING ARE SA VALUES IN INCHES AT THE TIME THE ABOVE SUMMARY WAS PRINTED:
ZONE= 1 2.0478 7.0470 0.1434 0.1500

THE FOLLOWING ARE RE-START VALUES TO APPROXIMATE WATERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

INITIAL STREAM FLO= 0.0

ZONE	% ASM1	% ASM2
1	13.146	17.082

RAIN-ET-RUNOFF-E-CN-SOIL-CHANNEL-DEPRESSIONS-OVERLAND-OFFSITE= -0.007
24.360 12.880 11.070 0.049 1.204 -0.837 0.0 0.0 0.0 0.0

SNOW= 0.0

STATISTICS

SUM OF OBSERVED = 0.11483963E 02 SUM OF SQUARE OF OBSERVED = 0.82691469E 01
SUM OF PREDICTED = 0.11070008E 02 SUM OF SQUARE OF PREDICTED = 0.31336193E 01
MEAN OF OBSERVED = 0.31291451E-01 MEAN OF PREDICTED = 0.30163508E-01

CORRELATION COEFFICIENT = 0.64622599E 00
STANDARD DEVIATION = 0.11203593E 00
COVARIANCE = 0.35804005E 01

APPENDIX V

INPUT PARAMETERS AND SUMMARY TABLE
FOR PITZEN FARM WATERSHED

USDAHL '74 MODEL OF WATERSHED HYDROLOGY

INDEX TEMPERATURE TO CONTROL THE CRITICAL VALUES

SNOW	FREEZING	MELT	ET	TIME OF MAX TEMP	TIME OF MIN TEMP
34.00	25.00	34.00	28.00	14.00	5.00

USDAHL-74 WATERSHED HYDROLOGY MODEL
W-1 PITZEN FARM, MOSCOW, IDAHO,1938 WATER YEAR

STORM HYDROGRAPHS WILL BE PRINTED FOR THE FOLLOWING DATES:

MO	DAY	(JULIAN)	YR												
12	26	87	38	12	27	88	38	12	28	89	38	12	29	90	38
12	30	91	38	1	13	105	38	1	14	106	38	1	15	107	38
1	16	108	38	1	17	109	38	1	18	110	48	1	19	111	38
3	14	165	38	3	15	166	38	3	16	167	38	3	17	168	38
3	18	169	38	3	19	170	38								

WATERSHED PARAMETERS

ACRES= 146.8 NUMBER OF ZONES= 3.0 RTG COEFF: TOTAL= 5.0 ABOVE WEIR= 5.0 NUMBER OF CROPS= 7.0

DEEP GROUND WATER RECHARGE= 0.00050 DOES LAND USE CHANGE? YES DOES YEARLY TILLAGE CHANGE? YES

GENERAL ZONE PARAMETERS

ZONE	% W/S	LENGTH	SLOPE	FC	DPTH TOP	AERATED DPTH
1	21.8	196.	10.00	0.060	9.0	60.0
2	75.1	676.	17.00	0.060	9.0	60.0
3	3.1	30.	5.00	0.080	9.0	60.0

SOIL PARAMETERS

ZONE	% G1	% AWC1	% ASM1	% CRAK1	% G2	% AWC2	% ASM2	% CRAK2
1	11.7	24.2	8.0	0.0	9.2	19.0	9.0	0.0
2	11.7	24.2	8.0	0.0	9.2	19.0	9.0	0.0
3	11.7	24.2	8.0	0.0	9.2	19.0	9.0	0.0

ROUTING PARAMETERS

CHANNEL ROUTING DELT T= 1.000 CHANNEL COEFFICIENT= 0.30 INITIAL STREAM FLO= 0.0 INITIAL SNOW COVER= 0.0

SUBSURFACE PARAMS

REGIME	Q-MAX	COEFFICIENT
1	0.02600	1.59
2	0.00900	6.59
3	0.00540	47.68
4	0.00100	700.00

COEFFICIENTS AND MAXIMUM Q'S PROPORTIONED TO ZONES ACCORDING TO TOPSOIL DEPTH

REGIME	M Z1	Q Z1	M Z2	Q Z2	M Z3	Q Z3
1	3.01	0.350385	6.16	0.170911	0.74	1.423138

2	21.66	0.216645	44.40	0.105675	5.33	0.879936
3	47.68	0.005400	47.68	0.005400	47.68	0.005400
4	700.00	0.001000	700.00	0.001000	700.00	0.001000

CASCADING PARAMETERS

ZONE	% TO NEXT ZONE	REST GOES TO?
1	100.0	ALLUVIUM
2	30.0	CHANNEL

(100% OF ALLUVIUM (ZONE 3) FLO GOES TO CHANNEL)
(%BASEFLO DIVERTED FROM ALLUVIUM= 0.0)

THE SOIL PARAMETERS IN INCHES FOLLOW.

ZONE	LAYER	G	AWC	SA	CRACKING	C(IN/HR)	TOPD	SOILD
1	1	1.053	2.178	2.511	0.0	0.2171	9.00	60.00
	2	4.692	9.690	9.792	0.0	0.0059		
	3	0.257	0.0	0.257	0.0	0.0015		
	4	0.700	0.0	0.700	0.0	0.0005		
2	1	1.053	2.178	2.511	0.0	0.1062	9.00	60.00
	2	4.692	9.690	9.792	0.0	0.0059		
	3	0.257	0.0	0.257	0.0	0.0015		
	4	0.700	0.0	0.700	0.0	0.0005		
3	1	1.053	2.178	2.511	0.0	0.8804	9.00	60.00
	2	4.692	9.690	9.792	0.0	0.0059		
	3	0.257	0.0	0.257	0.0	0.0015		
	4	0.700	0.0	0.700	0.0	0.0005		

LAND USE PARAMETERS

	WINWHEAT	PEAS	GRASS	OATS	FALLOW	CLOVER	WINBAREY
A VALUES	0.25	0.25	0.50	0.25	0.25	0.60	0.25
CROP VD	0.05	0.05	0.05	0.05	0.05	0.05	0.05
ETEP	1.20	1.30	1.20	1.20	1.20	1.20	1.20
ROOT DEPTH	24.00	36.00	36.00	24.00	24.00	30.00	24.00
UPPER TEMP	93.00	90.00	95.00	90.00	93.00	90.00	93.00
LOWER TEMP	35.00	33.00	33.00	33.00	35.00	40.00	35.00

TILLAGE WILL BE READ YEARLY.

CROP	% GRAZING	TILLAGE PRACTICES
WINWHEAT	0	PLA 101538 HAR 8 138 PLO 93038
PEAS	0	PLO 42138 PLA 5 138 HAR 81538 PLO 9 138
GRASS	0	NONE
OATS	0	NONE
FALLOW	0	NONE
CLOVER	0	NONE
WINBAREY	0	NONE

GI CURVES

WEEK	TEMP	WINWHEAT	PEAS	GRASS	OATS	FALLOW	CLOVER	WINBAREY
1	46.50	0.30	0.30	0.30	0.30	0.30	0.30	0.30
2	56.57	0.37	0.41	0.38	0.41	0.37	0.33	0.37
3	48.71	0.10	0.30	0.30	0.30	0.30	0.30	0.30
4	58.07	0.14	0.44	0.40	0.44	0.40	0.36	0.40
5	44.21	0.18	0.30	0.30	0.30	0.30	0.30	0.30
6	43.43	0.22	0.30	0.30	0.30	0.30	0.30	0.30
7	41.29	0.26	0.30	0.30	0.30	0.30	0.30	0.30
8	41.21	0.29	0.30	0.30	0.30	0.30	0.30	0.30
9	36.00	0.30	0.30	0.30	0.30	0.30	0.30	0.30
10	30.50	0.30	0.30	0.30	0.30	0.30	0.30	0.30
11	38.14	0.30	0.30	0.30	0.30	0.30	0.30	0.30
12	32.21	0.30	0.30	0.30	0.30	0.30	0.30	0.30
13	34.43	0.30	0.30	0.30	0.30	0.30	0.30	0.30
14	29.29	0.30	0.30	0.30	0.30	0.30	0.30	0.30
15	31.36	0.30	0.30	0.30	0.30	0.30	0.30	0.30
16	35.79	0.30	0.30	0.30	0.30	0.30	0.30	0.30
17	35.43	0.30	0.30	0.30	0.30	0.30	0.30	0.30
18	29.57	0.30	0.30	0.30	0.30	0.30	0.30	0.30
19	33.21	0.30	0.30	0.30	0.30	0.30	0.30	0.30
20	30.71	0.30	0.30	0.30	0.30	0.30	0.30	0.30
21	33.14	0.30	0.30	0.30	0.30	0.30	0.30	0.30
22	39.50	0.30	0.30	0.30	0.30	0.30	0.30	0.30
23	40.71	0.30	0.30	0.30	0.30	0.30	0.30	0.30
24	40.93	0.30	0.30	0.30	0.30	0.30	0.30	0.30
25	34.64	0.30	0.30	0.30	0.30	0.30	0.30	0.30
26	37.43	0.30	0.30	0.30	0.30	0.30	0.30	0.30
27	41.43	0.30	0.30	0.30	0.30	0.30	0.30	0.30
28	44.36	0.30	0.30	0.30	0.30	0.30	0.30	0.30
29	47.14	0.30	1.00	0.30	0.30	0.30	0.30	0.30
30	51.36	0.30	0.75	0.30	0.32	0.30	0.30	0.30
31	47.50	0.30	0.10	0.30	0.30	0.30	0.30	0.30
32	50.14	0.30	0.13	0.30	0.30	0.30	0.30	0.30
33	52.71	0.31	0.18	0.32	0.35	0.31	0.30	0.31
34	63.43	0.49	0.31	0.49	0.53	0.49	0.47	0.49
35	60.50	0.44	0.40	0.44	0.48	0.44	0.41	0.44
36	60.71	0.44	0.45	0.45	0.49	0.44	0.41	0.44
37	62.29	0.47	0.50	0.47	0.51	0.47	0.45	0.47
38	60.71	0.44	0.49	0.45	0.49	0.44	0.41	0.44
39	69.29	0.59	0.64	0.59	0.64	0.59	0.59	0.59
40	62.21	0.47	0.51	0.47	0.51	0.47	0.44	0.47
41	68.79	0.58	0.63	0.58	0.63	0.58	0.58	0.58
42	78.00	0.74	0.79	0.73	0.79	0.74	0.76	0.74
43	74.14	0.67	0.72	0.66	0.72	0.67	0.68	0.67
44	66.29	0.16	0.58	0.54	0.58	0.54	0.53	0.54
45	64.14	0.25	0.55	0.50	0.55	0.50	0.48	0.50
46	59.71	0.34	0.14	0.43	0.47	0.43	0.39	0.43
47	65.57	0.48	0.25	0.53	0.57	0.53	0.51	0.53
48	72.29	0.64	1.00	0.63	0.69	0.64	0.65	0.64
49	63.50	0.49	0.75	0.49	0.54	0.49	0.47	0.49
50	65.57	0.53	0.10	0.53	0.57	0.53	0.51	0.53
51	72.29	0.64	0.10	0.63	0.69	0.64	0.65	0.64
52	64.79	1.00	0.10	0.51	0.56	0.51	0.50	0.51

LAND USE FOR YEAR 1938 FOLLOWS. IF A ZONE IS NOT MENTIONED, VALUES OF PREVIOUS YEAR ARE ASSUMED.

ZONE 1	WINWHEAT= 19.0%	PEAS = 81.0%	GRASS = 0.0%	OATS = 0.0%	FALLOW = 0.0%	CLOVER = 0.0%
	WINBAREY= 0.0%					
ZONE 2	WINWHEAT= 32.6%	PEAS = 67.4%	GRASS = 0.0%	OATS = 0.0%	FALLOW = 0.0%	CLOVER = 0.0%
	WINBAREY= 0.0%					
ZONE 3	WINWHEAT= 21.4%	PEAS = 50.0%	GRASS = 28.6%	OATS = 0.0%	FALLOW = 0.0%	CLOVER = 0.0%
	WINBAREY= 0.0%					

PAN EVAPORATION FOR YEAR 1938 FOLLOWS.

WEEK 1	0.114	0.097	0.080	0.063
WEEK 5	0.042	0.042	0.042	0.042
WEEK 9	0.042	0.016	0.016	0.016
WEEK 13	0.016	0.016	0.016	0.016
WEEK 17	0.016	0.027	0.027	0.027
WEEK 21	0.027	0.065	0.065	0.065
WEEK 25	0.065	0.065	0.147	0.090
WEEK 29	0.113	0.127	0.138	0.150
WEEK 33	0.163	0.165	0.172	0.178
WEEK 37	0.181	0.162	0.256	0.233
WEEK 41	0.301	0.272	0.331	0.301
WEEK 45	0.270	0.281	0.219	0.194
WEEK 49	0.176	0.164	0.197	0.161

THE FOLLOWING IS A MONTHLY SUMMARY OF WATER YIELDS 1938:

	RAIN+				RETURN FLOW		
MONTH	MELT	ET	EVAP	RUNOFF	ONSITE	OFFSITE	GR
1	1.320	0.363	0.0	0.0	0.0	0.0	0.0
2	3.550	0.418	0.005	0.010	0.0	0.0	0.0
3	4.199	0.163	0.005	1.245	0.523	0.0	0.057
4	1.700	0.144	0.002	1.144	1.020	0.0	0.372
5	1.791	0.298	0.002	1.239	1.144	0.0	0.336
6	1.940	0.728	0.011	0.886	0.695	0.0	0.372
7	1.520	2.176	0.004	0.343	0.311	0.0	0.286
8	1.470	1.583	0.0	0.005	0.005	0.0	0.009
9	1.140	3.161	0.0	0.0	0.0	0.0	0.0
10	0.110	3.239	0.0	0.0	0.0	0.0	0.0
11	0.180	0.603	0.0	0.0	0.0	0.0	0.0
12	0.750	0.287	0.0	0.0	0.0	0.0	0.0
TOTAL	19.670	13.162	0.028	4.873	3.698	0.0	1.432

	ZONE 1				ZONE 2				ZONE 3			
		RETURN FLOW				RETURN FLOW				RETURN FLOW		
MO	QO	ONSITE	OFFSITE	GR	QO	ONSITE	OFFSITE	GR	QO	ONSITE	OFFSITE	GR
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.00	0.01	0.0	0.0	0.00	0.04	0.0	0.0	0.31	0.0	0.0	0.0
3	0.41	0.85	0.0	0.05	0.50	0.86	0.0	0.05	14.72	16.88	0.0	0.17
4	0.0	1.15	0.0	0.37	0.0	1.15	0.0	0.37	3.99	32.91	0.0	0.37
5	0.0	1.25	0.0	0.34	0.0	1.24	0.0	0.34	3.06	36.89	0.0	0.34
6	0.03	0.83	0.0	0.37	0.03	0.88	0.0	0.37	5.63	22.43	0.0	0.37
7	0.0	0.35	0.0	0.27	0.0	0.34	0.0	0.29	1.05	10.02	0.0	0.36
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.15	0.0	0.28
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	0.44	4.43	0.0	1.40	0.54	4.51	0.0	1.42	28.77	119.29	0.0	1.89

THE FOLLOWING ARE SA VALUES IN INCHES AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

ZONE=	1	2.2639	9.8220	0.2575	0.7000
ZONE=	2	2.3084	9.8220	0.2575	0.7000
ZONE=	3	2.3376	9.8220	0.2575	0.7000

THE FOLLOWING ARE RE-START VALUES TO APPROXIMATE WATERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

INITIAL STREAM FLO= 0.0

ZONE	% ASM1	% ASM2
1	10.746	8.941
2	10.251	8.941
3	9.926	8.941

RAIN-ET-RUNOFF-E-CN-SOIL-CHANNEL-DEPRESSIONS-OVERLAND-OFFSITE= -0.007
19.670 13.162 4.873 0.028 1.432 0.181 0.0 0.0 0.0 0.0

SNOW= 0.0

STATISTICS

SUM OF OBSERVED = 0.51452465E 01 SUM OF SQUARE OF OBSERVED = 0.36378407E 00
SUM OF PREDICTED = 0.48725691E 01 SUM OF SQUARE OF PREDICTED = 0.66333264E 00
MEAN OF OBSERVED = 0.14058050E-01 MEAN OF PREDICTED = 0.13313029E-01

CORRELATION COEFFICIENT = 0.0
STANDARD DEVIATION = 0.36204018E-01
COVARIANCE = 0.25753222E 01

LAND USE FOR YEAR 1939 FOLLOWS. IF A ZONE IS NOT MENTIONED, VALUES OF PREVIOUS YEAR ARE ASSUMED.

ZONE 1 WINWHEAT= 48.0% PEAS = 26.0% GRASS = 0.0% OATS = 26.0% FALLOW = 0.0% CLOVER = 0.0%
WINBAREY= 0.0%

ZONE 2 WINWHEAT= 32.6% PEAS = 42.1% GRASS = 0.0% OATS = 20.8% FALLOW = 4.5% CLOVER = 0.0%
WINBAREY= 0.0%

ZONE 3 WINWHEAT= 0.0% PEAS = 21.4% GRASS = 28.6% OATS = 0.0% FALLOW = 50.0% CLOVER = 0.0%
WINBAREY= 0.0%

PAN EVAPORATION FOR YEAR 1939 FOLLOWS.

WEEK 1	0.114	0.097	0.080	0.063
WEEK 5	0.042	0.042	0.042	0.042
WEEK 9	0.042	0.016	0.016	0.016
WEEK 13	0.016	0.016	0.016	0.016
WEEK 17	0.016	0.027	0.027	0.027
WEEK 21	0.027	0.065	0.065	0.065
WEEK 25	0.065	0.065	0.147	0.090
WEEK 29	0.113	0.127	0.138	0.150
WEEK 33	0.163	0.165	0.172	0.178
WEEK 37	0.184	0.200	0.220	0.238
WEEK 41	0.257	0.275	0.260	0.254
WEEK 45	0.248	0.241	0.227	0.206
WEEK 49	0.185	0.164	0.149	0.131

THE FOLLOWING IS A MONTHLY SUMMARY OF WATER YIELDS 1939:

MONTH	RAIN+ MELT	ET	EVAP	RUNOFF	RETURN FLOW ONSITE	RETURN FLOW OFFSITE	GR
1	1.640	0.505	0.007	0.009	0.0	0.0	0.0
2	2.369	0.372	0.003	0.018	0.0	0.0	0.0
3	1.241	0.134	0.000	0.0	0.0	0.0	0.0
4	1.510	0.185	0.000	0.002	0.002	0.0	0.001
5	3.435	0.219	0.014	2.017	0.830	0.0	0.205
6	2.565	0.694	0.020	1.853	0.988	0.0	0.372
7	0.370	1.878	0.001	0.023	0.017	0.0	0.088
8	0.920	1.508	0.0	0.000	0.000	0.0	0.003
9	0.790	2.297	0.0	0.0	0.0	0.0	0.0
10	0.770	2.832	0.0	0.0	0.0	0.0	0.0
11	0.0	0.847	0.0	0.0	0.0	0.0	0.0
12	0.390	0.194	0.0	0.0	0.0	0.0	0.0
TOTAL	16.000	11.665	0.046	3.923	1.837	0.0	0.669

MO	ZONE 1 RETURN FLOW QO	ONSITE	OFFSITE	GR	ZONE 2 RETURN FLOW QO	ONSITE	OFFSITE	GR	ZONE 3 RETURN FLOW QO	ONSITE	OFFSITE	GR
1	0.02	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.04	0.0	0.0	0.0
2	0.0	0.00	0.0	0.0	0.0	0.04	0.0	0.0	0.57	0.0	0.0	0.0
3	0.0	0.00	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.01	0.0	0.0	0.0	0.01	0.0	0.0	0.00	0.07	0.0	0.04
5	0.38	1.72	0.0	0.20	0.49	1.61	0.0	0.20	30.09	26.76	0.0	0.30
6	0.03	1.87	0.0	0.37	0.02	1.86	0.0	0.37	27.54	31.88	0.0	0.37
7	0.01	0.01	0.0	0.07	0.01	0.01	0.0	0.08	0.07	0.54	0.0	0.36
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.09
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	0.44	3.62	0.0	0.64	0.53	3.54	0.0	0.66	58.31	59.27	0.0	1.16

THE FOLLOWING ARE SA VALUES IN INCHES AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

ZONE=	1	2.6212	9.8220	0.2575	0.7000
ZONE=	2	2.6250	9.8220	0.2575	0.7000
ZONE=	3	2.6228	9.8220	0.2575	0.7000

THE FOLLOWING ARE RE-START VALUES TO APPROXIMATE WATERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

INITIAL STREAM FLO= 0.0

ZONE	% ASM1	% ASM2
1	6.776	8.941
2	6.734	8.941
3	6.758	8.941

RAIN-ET-RUNOFF-E-CN-SOIL-CHANNEL-DEPRESSIONS-OVERLAND-OFFSITE= -0.004
16.000 11.665 3.923 0.046 0.669 -0.298 0.0 0.0 0.0 0.0

SNOW= 0.0

STATISTICS

SUM OF OBSERVED = 0.52433796E 01 SUM OF SQUARE OF OBSERVED = 0.16336508E 01
SUM OF PREDICTED = 0.39226122E 01 SUM OF SQUARE OF PREDICTED = 0.11567278E 01
MEAN OF OBSERVED = 0.14326170E-01 MEAN OF PREDICTED = 0.10717519E-01

CORRELATION COEFFICIENT = 0.0
STANDARD DEVIATION = 0.77631414E-01
COVARIANCE = 0.54188528E 01

LAND USE FOR YEAR 1940 FOLLOWS. IF A ZONE IS NOT MENTIONED, VALUES OF PREVIOUS YEAR ARE ASSUMED.

ZONE 1 WINWHEAT= 19.0% PEAS = 48.0% GRASS = 0.0% OATS = 27.0% FALLOW = 0.0% CLOVER = 0.0%
WINBAREY= 6.0%

ZONE 2 WINWHEAT= 34.7% PEAS = 32.6% GRASS = 4.5% OATS = 9.5% FALLOW = 0.0% CLOVER = 11.3%
WINBAREY= 7.4%

ZONE 3 WINWHEAT= 21.4% PEAS = 0.0% GRASS = 78.6% OATS = 0.0% FALLOW = 0.0% CLOVER = 0.0%
WINBAREY= 0.0%

PAN EVAPORATION FOR YEAR 1940 FOLLOWS.

WEEK 1	0.114	0.097	0.080	0.063
WEEK 5	0.042	0.042	0.042	0.042
WEEK 9	0.042	0.016	0.016	0.016
WEEK 13	0.016	0.016	0.016	0.016
WEEK 17	0.016	0.027	0.027	0.027
WEEK 21	0.027	0.065	0.065	0.065
WEEK 25	0.065	0.065	0.147	0.090
WEEK 29	0.124	0.100	0.068	0.150
WEEK 33	0.128	0.237	0.153	0.171
WEEK 37	0.300	0.270	0.311	0.233
WEEK 41	0.274	0.211	0.190	0.184
WEEK 45	0.240	0.206	0.266	0.203
WEEK 49	0.164	0.127	0.084	0.106

THE FOLLOWING IS A MONTHLY SUMMARY OF WATER YIELDS 1940:

	RAIN+				RETURN FLOW		
MONTH	MELT	ET	EVAP	RUNOFF	ONSITE	OFFSITE	GR
1	1.190	0.240	0.0	0.0	0.0	0.0	0.0
2	0.280	0.254	0.0	0.0	0.0	0.0	0.0
3	4.250	0.136	0.002	0.050	0.000	0.0	0.0
4	1.723	0.132	0.001	0.038	0.038	0.0	0.018
5	4.717	0.350	0.016	2.615	1.742	0.0	1.252
6	3.070	0.800	0.012	1.265	0.688	0.0	0.994
7	2.180	1.268	0.008	0.406	0.388	0.0	0.635
8	0.840	2.315	0.007	0.187	0.150	0.0	0.354
9	0.500	3.265	0.0	0.0	0.0	0.0	0.0
10	1.730	2.169	0.0	0.0	0.0	0.0	0.0
11	0.0	1.531	0.0	0.0	0.0	0.0	0.0
12	4.100	1.408	0.010	0.084	0.000	0.0	0.0
TOTAL	24.580	13.868	0.056	4.644	3.005	0.0	3.254

	ZONE 1				ZONE 2				ZONE 3			
		RETURN FLOW				RETURN FLOW				RETURN FLOW		
MO	QO	ONSITE	OFFSITE	GR	QO	ONSITE	OFFSITE	GR	QO	ONSITE	OFFSITE	GR
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.03	0.01	0.0	0.0	0.02	0.09	0.0	0.0	1.22	0.01	0.0	0.0
4	0.00	0.00	0.0	0.0	0.0	0.02	0.0	0.0	0.01	1.21	0.0	0.58
5	0.0	2.70	0.0	1.26	0.0	2.65	0.0	1.25	28.18	56.18	0.0	1.27
6	0.0	1.27	0.0	0.98	0.0	1.28	0.0	0.98	18.61	22.18	0.0	1.49
7	0.00	0.40	0.0	0.59	0.0	0.44	0.0	0.62	0.57	12.52	0.0	1.33
8	0.02	0.17	0.0	0.34	0.01	0.19	0.0	0.34	1.09	4.84	0.0	0.74
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.01	0.00	0.0	0.0	0.00	0.15	0.0	0.0	2.63	0.01	0.0	0.0
TOTAL	0.07	4.55	0.0	3.16	0.03	4.82	0.0	3.19	52.31	96.94	0.0	5.41

THE FOLLOWING ARE SA VALUES IN INCHES AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

ZONE=	1	1.0549	8.5434	0.2575	0.7000
ZONE=	2	1.0550	8.7230	0.2575	0.7000
ZONE=	3	1.0547	7.4571	0.2575	0.7000

THE FOLLOWING ARE RE-START VALUES TO APPROXIMATE WATERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

INITIAL STREAM FLO= 0.0

ZONE	% ASM1	% ASM2
1	24.179	11.448
2	24.178	11.096
3	24.181	13.578

RAIN-ET-RUNOFF-E-CN-SOIL-CHANNEL-DEPRESSIONS-OVERLAND-OFFSITE= -0.005
24.580 13.868 4.644 0.056 3.254 2.763 0.0 0.0 0.0 0.0

SNOW= 0.0

STATISTICS

SUM OF OBSERVED = 0.37267618E 01 SUM OF SQUARE OF OBSERVED = 0.44272232E 00
SUM OF PREDICTED = 0.46437817E 01 SUM OF SQUARE OF PREDICTED = 0.80696160E 00
MEAN OF OBSERVED = 0.10154661E-01 MEAN OF PREDICTED = 0.12653355E-01

CORRELATION COEFFICIENT = 0.59309816E 00
STANDARD DEVIATION = 0.26742086E-01
COVARIANCE = 0.26334782E 01

APPENDIX VI

INPUT PARAMETERS AND SUMMARY TABLE
FOR MISSOURI FLAT CREEK WATERSHED

USDAHL '74 MODEL OF WATERSHED HYDROLOGY

INDEX TEMPERATURE TO CONTROL THE CRITICAL VALUES

SNOW	FREEZING	MELT	ET	TIME OF MAX TEMP	TIME OF MIN TEMP
34.00	25.00	34.00	28.00	14.00	5.00

USDAHL-74 WATERSHED HYDROLOGY MODEL
MISSOURI FLAT CREEK, PULLMAN, WASH, 1961 WATER YEAR

STORM HYDROGRAPHS WILL BE PRINTED FOR THE FOLLOWING DATES:

MO	DAY	(JULIAN)	YR												
10	7	7	61	11	10	41	61	11	15	46	61	11	16	47	61
11	23	54	61	11	24	55	61	11	25	56	61	12	18	79	61
12	26	87	61	12	31	92	61	1	5	97	61	1	6	98	61
1	7	99	61	1	8	100	61	1	9	101	61	1	29	121	61
1	30	122	61	1	31	123	61	2	1	124	61	2	2	125	61
2	3	126	61	2	8	131	61	2	9	132	61	2	10	133	61
2	11	134	61	2	12	135	61	2	13	136	61	2	14	137	61
2	15	138	61	2	16	139	61	2	17	140	61	2	18	141	61
2	19	142	61	2	20	143	61	2	21	144	61	2	22	145	61
2	23	146	61	2	24	147	61	2	25	148	61	2	26	149	61
2	27	150	61	2	28	151	61	3	1	152	61	3	2	153	61
3	3	154	61	3	4	155	61								

WATERSHED PARAMETERS

ACRES= 17600.0 NUMBER OF ZONES= 3.0 RTG COEFF: TOTAL= 5.0 ABOVE WEIR= 5.0 NUMBER OF CROPS= 9.0

DEEP GROUND WATER RECHARGE= 0.00250 DOES LAND USE CHANGE? YES DOES YEARLY TILLAGE CHANGE? YES

GENERAL ZONE PARAMETERS

ZONE	% W/S	LENGTH	SLOPE	FC	DPTH TOP	AERATED DPTH
1	89.5	7160.	15.00	0.060	9.0	72.0
2	1.8	144.	5.00	0.060	9.0	72.0
3	8.7	696.	2.00	0.080	9.0	72.0

SOIL PARAMETERS

ZONE	% G1	% AWC1	% ASM1	% CRAK1	% G2	% AWC2	% ASM2	% CRAK2
1	11.7	24.2	6.5	0.0	9.2	19.0	8.5	0.0
2	11.7	24.2	6.5	0.0	9.2	19.0	8.5	0.0
3	11.7	24.2	6.5	0.0	9.2	19.0	8.5	0.0

ROUTING PARAMETERS

CHANNEL ROUTING DELT T= 0.500 CHANNEL COEFFICIENT= 2.17 INITIAL STREAM FLO= 0.0 INITIAL SNOW COVER= 0.0

SUBSURFACE PARAMS

REGIME	Q-MAX	COEFFICIENT
1	0.01800	13.00
2	0.00700	43.50

3	0.00100	146.00
4	0.00050	1250.00

COEFFICIENTS AND MAXIMUM Q'S PROPORTIONED TO ZONES ACCORDING TO TOPSOIL DEPTH

REGIME	M Z1	Q Z1	M Z2	Q Z2	M Z3	Q Z3
1	5.47	0.192666	0.33	3.224951	2.96	0.356230
2	48.65	0.119127	2.91	1.994010	26.31	0.220260
3	146.00	0.001000	146.00	0.001000	146.00	0.001000
4	1250.00	0.000500	1250.00	0.000500	1250.00	0.000500

CASCADING PARAMETERS

ZONE	% TO NEXT ZONE	REST GOES TO?
1	20.0	CHANNEL
2	50.0	CHANNEL

(100% OF ALLUVIUM (ZONE 3) FLO GOES TO CHANNEL)
(%BASEFLO DIVERTED FROM ALLUVIUM= 0.0)

THE SOIL PARAMETERS IN INCHES FOLLOW.

ZONE	LAYER	G	AWC	SA	CRACKING	C(IN/HR)	TOPD	SOILD
1	1	1.053	2.178	2.646	0.0	0.1216	9.00	72.00
	2	5.796	11.970	12.411	0.0	0.0035		
	3	0.146	0.0	0.146	0.0	0.0030		
	4	0.625	0.0	0.625	0.0	0.0025		
2	1	1.053	2.178	2.646	0.0	1.9965	9.00	72.00
	2	5.796	11.970	12.411	0.0	0.0035		
	3	0.146	0.0	0.146	0.0	0.0030		
	4	0.625	0.0	0.625	0.0	0.0025		
3	1	1.053	2.178	2.646	0.0	0.2228	9.00	72.00
	2	5.796	11.970	12.411	0.0	0.0035		
	3	0.146	0.0	0.146	0.0	0.0030		
	4	0.625	0.0	0.625	0.0	0.0025		

LAND USE PARAMETERS

	WINWHEAT	SPGRAIN	PEAS	CLOVER	ALFALFA	PASTURE	WOOD	MISC	FALLOW
A VALUES	0.25	0.30	0.25	0.60	0.50	0.70	1.00	0.40	0.25
CROP VD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.02	0.05
ETEP	1.20	1.20	1.30	1.20	1.20	1.00	2.00	1.00	1.20
ROOT DEPTH	24.00	24.00	36.00	30.00	36.00	36.00	72.00	2.00	24.00
UPPER TEMP	93.00	90.00	90.00	90.00	95.00	90.00	90.00	90.00	93.00
LOWER TEMP	35.00	32.00	33.00	40.00	33.00	32.00	35.00	32.00	35.00

TILLAGE WILL BE READ YEARLY.

CROP	% GRAZING	TILLAGE PRACTICES
WINWHEAT	0	PLA 10 161 HAR 8 161 PLO 91561
SPGRAIN	0	PLO 41561 PLA 5 161 HAR 8 161 PLO 81561
PEAS	0	PLO 42161 PLA 5 161 HAR 8 161 PLO 81561
CLOVER	0	NONE
ALFALFA	0	NONE
PASTURE	0	NONE
WOOD	0	NONE

MISC	0	NONE
FALLOW	0	CUL 5 161 CUL 6 161 CUL 7 161

GI CURVES

WEEK	TEMP	WINWHEAT	SPGRAIN	PEAS	CLOVER	ALFALFA	PASTURE	WOOD	MISC	FALLOW
1	58.14	0.10	0.45	0.44	0.36	0.41	0.45	0.42	0.45	0.40
2	43.14	0.12	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
3	50.50	0.17	0.32	0.31	0.30	0.30	0.32	0.30	0.32	0.30
4	50.00	0.22	0.31	0.30	0.30	0.30	0.31	0.30	0.31	0.30
5	39.07	0.26	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
6	37.71	0.28	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
7	39.00	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
8	38.64	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
9	33.14	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
10	27.21	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
11	31.36	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
12	32.57	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
13	27.07	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
14	25.93	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
15	38.29	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
16	39.64	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
17	26.43	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
18	35.86	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
19	40.36	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
20	38.36	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
21	40.50	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
22	34.29	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
23	36.00	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
24	42.71	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
25	42.64	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
26	42.21	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
27	43.43	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
28	42.14	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
29	43.93	0.30	1.00	1.00	0.30	0.30	0.30	0.30	0.30	0.30
30	45.14	0.30	0.75	0.75	0.30	0.30	0.30	0.30	0.30	0.30
31	48.00	0.30	0.10	0.10	0.30	0.30	0.30	0.30	0.30	0.27
32	48.71	0.30	0.12	0.12	0.30	0.30	0.30	0.30	0.30	0.30
33	52.64	0.30	0.18	0.18	0.30	0.32	0.36	0.32	0.36	0.30
34	58.43	0.40	0.29	0.28	0.37	0.41	0.46	0.43	0.46	0.40
35	58.00	0.40	0.37	0.36	0.36	0.40	0.45	0.42	0.45	0.36
36	62.43	0.47	0.47	0.46	0.45	0.47	0.52	0.50	0.52	0.47
37	67.86	0.48	0.52	0.51	0.46	0.48	0.53	0.51	0.53	0.48
38	69.64	0.60	0.63	0.63	0.59	0.59	0.65	0.63	0.65	0.60
39	62.57	0.48	0.53	0.52	0.45	0.48	0.53	0.50	0.53	0.48
40	64.64	0.51	0.56	0.56	0.49	0.51	0.56	0.54	0.56	0.46
41	69.21	0.59	0.64	0.64	0.58	0.58	0.64	0.62	0.64	0.59
42	70.43	0.61	0.66	0.66	0.61	0.60	0.66	0.64	0.66	0.61
43	69.57	0.60	0.65	0.64	0.59	0.59	0.65	0.63	0.65	0.60
44	72.86	0.20	0.21	0.21	0.66	0.64	0.70	0.69	0.70	0.65
45	68.79	0.29	0.32	0.31	0.58	0.58	0.63	0.61	0.63	0.58
46	70.79	0.45	1.00	1.00	0.62	0.61	0.67	0.65	0.67	0.62
47	74.64	0.63	0.75	0.75	0.69	0.67	0.74	0.72	0.74	0.68
48	65.43	0.52	0.10	0.10	0.51	0.52	0.58	0.55	0.58	0.52
49	56.57	0.37	0.10	0.10	0.33	0.38	0.42	0.39	0.42	0.37
50	58.07	1.00	0.10	0.10	0.36	0.40	0.45	0.42	0.45	0.40
51	52.57	0.75	0.10	0.10	0.30	0.32	0.35	0.32	0.35	0.30
52	49.14	0.10	0.10	0.10	0.30	0.30	0.30	0.30	0.30	0.30

LAND USE FOR YEAR 1961 FOLLOWS. IF A ZONE IS NOT MENTIONED, VALUES OF PREVIOUS YEAR ARE ASSUMED.

ZONE 1 WINWHEAT= 39.3% SPGRAIN = 10.7% PEAS = 35.8% CLOVER = 0.0% ALFALFA = 0.0% PASTURE = 3.3%
WOOD = 2.0% MISC = 3.9% FALLOW = 5.0%

ZONE 2 WINWHEAT= 0.0% SPGRAIN = 0.0% PEAS = 0.0% CLOVER =100.0% ALFALFA = 0.0% PASTURE = 0.0%
WOOD = 0.0% MISC = 0.0% FALLOW = 0.0%

ZONE 3 WINWHEAT= 81.4% SPGRAIN = 0.0% PEAS = 0.0% CLOVER = 0.0% ALFALFA = 0.0% PASTURE = 14.7%
WOOD = 0.0% MISC = 0.0% FALLOW = 3.7%

PAN EVAPORATION FOR YEAR 1961 FOLLOWS.

WEEK 1	0.154	0.099	0.140	0.100
WEEK 5	0.042	0.042	0.042	0.042
WEEK 9	0.042	0.016	0.016	0.016
WEEK 13	0.016	0.016	0.016	0.016
WEEK 17	0.016	0.027	0.027	0.027
WEEK 21	0.027	0.065	0.065	0.065
WEEK 25	0.065	0.065	0.117	0.083
WEEK 29	0.104	0.100	0.251	0.104
WEEK 33	0.163	0.251	0.177	0.226
WEEK 37	0.157	0.250	0.257	0.299
WEEK 41	0.264	0.307	0.320	0.370
WEEK 45	0.319	0.267	0.241	0.210
WEEK 49	0.151	0.256	0.184	0.176

THE FOLLOWING IS A MONTHLY SUMMARY OF WATER YIELDS 1961:

MONTH	RAIN+ MELT	ET	EVAP	RUNOFF	RETURN FLOW ONSITE	RETURN FLOW OFFSITE	GR
1	2.230	0.670	0.000	0.000	0.000	0.0	0.0
2	5.709	0.404	0.008	0.013	0.003	0.0	0.0
3	1.970	0.126	0.002	0.255	0.223	0.0	0.225
4	2.550	0.128	0.008	1.013	0.884	0.0	0.675
5	6.101	0.332	0.026	4.458	3.835	0.0	1.666
6	2.670	0.713	0.009	0.992	0.945	0.0	1.419
7	1.630	1.569	0.000	0.028	0.028	0.0	0.102
8	1.420	2.053	0.000	0.001	0.001	0.0	0.006
9	1.350	3.786	0.000	0.0	0.0	0.0	0.0
10	0.130	3.470	0.0	0.0	0.0	0.0	0.0
11	0.680	1.483	0.0	0.0	0.0	0.0	0.0
12	1.230	1.054	0.0	0.0	0.0	0.0	0.0
TOTAL	27.669	15.788	0.054	6.760	5.919	0.0	4.093

	ZONE 1				ZONE 2				ZONE 3			
	RETURN FLOW				RETURN FLOW				RETURN FLOW			
MO	QD	ONSITE	OFFSITE	GR	QD	ONSITE	OFFSITE	GR	QD	ONSITE	OFFSITE	GR
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0
2	0.00	0.11	0.0	0.0	0.00	0.0	0.0	0.0	0.08	0.03	0.0	0.0
3	0.0	0.19	0.0	0.17	0.0	0.46	0.0	0.09	0.37	2.56	0.0	0.82
4	0.00	1.24	0.0	0.65	0.0	2.10	0.0	0.31	1.46	10.16	0.0	1.03
5	0.01	4.28	0.0	1.68	0.0	5.04	0.0	0.93	7.10	44.08	0.0	1.68
6	0.00	1.00	0.0	1.40	0.0	1.73	0.0	0.38	0.51	10.87	0.0	1.86
7	0.0	0.01	0.0	0.06	0.0	0.33	0.0	0.10	0.0	0.32	0.0	0.58
8	0.0	0.00	0.0	0.0	0.0	0.01	0.0	0.02	0.0	0.02	0.0	0.07
9	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	0.02	6.84	0.0	3.95	0.00	9.66	0.0	1.83	9.52	68.04	0.0	6.04

THE FOLLOWING ARE SA VALUES IN INCHES AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

ZONE=	1	1.8703	12.3610	0.1460	0.6250
ZONE=	2	1.9056	9.7860	0.1460	0.6250
ZONE=	3	2.0635	10.9260	0.1460	0.6250

THE FOLLOWING ARE RE-START VALUES TO APPROXIMATE WATERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

INITIAL STREAM FLO= 0.0

ZONE	% ASM1	% ASM2
1	15.119	8.579
2	14.726	12.667
3	12.973	10.857

RAIN-ET-RUNOFF-E-CN-SOIL-CHANNEL-DEPRESSIONS-OVERLAND-OFFSITE= -0.005

27.669 15.788 6.760 0.054 4.093 0.979 0.0 0.0 0.0 0.0

SNOW= 0.0

STATISTICS

SUM OF OBSERVED = 0.61049261E 01 SUM OF SQUARE OF OBSERVED = 0.82094073E 00
SUM OF PREDICTED = 0.67600164E 01 SUM OF SQUARE OF PREDICTED = 0.12474051E 01
MEAN OF OBSERVED = 0.16680125E-01 MEAN OF PREDICTED = 0.18469989E-01

CORRELATION COEFFICIENT = 0.74177390E 00
STANDARD DEVIATION = 0.29727127E-01
COVARIANCE = 0.17821884E 01

LAND USE FOR YEAR 1962 FOLLOWS. IF A ZONE IS NOT MENTIONED, VALUES OF PREVIOUS YEAR ARE ASSUMED.

ZONE 1 WINWHEAT= 39.3% SPGRAIN = 10.7% PEAS = 35.8% CLOVER = 0.0% ALFALFA = 0.0% PASTURE = 3.3%
WOOD = 2.0% MISC = 3.9% FALLOW = 5.0%

ZONE 2 WINWHEAT= 0.0% SPGRAIN = 0.0% PEAS = 0.0% CLOVER =100.0% ALFALFA = 0.0% PASTURE = 0.0%
WOOD = 0.0% MISC = 0.0% FALLOW = 0.0%

ZONE 3 WINWHEAT= 81.4% SPGRAIN = 0.0% PEAS = 0.0% CLOVER = 0.0% ALFALFA = 0.0% PASTURE = 14.7%
WOOD = 0.0% MISC = 0.0% FALLOW = 3.7%

PAN EVAPORATION FOR YEAR 1962 FOLLOWS.

WEEK 1	0.114	0.097	0.080	0.063
WEEK 5	0.042	0.042	0.042	0.042
WEEK 9	0.042	0.016	0.016	0.016
WEEK 13	0.016	0.016	0.016	0.016
WEEK 17	0.016	0.027	0.027	0.027
WEEK 21	0.027	0.065	0.065	0.065
WEEK 25	0.065	0.065	0.106	0.161
WEEK 29	0.180	0.193	0.110	0.099
WEEK 33	0.174	0.080	0.139	0.150
WEEK 37	0.180	0.283	0.250	0.244
WEEK 41	0.299	0.299	0.299	0.279
WEEK 45	0.159	0.270	0.293	0.194
WEEK 49	0.277	0.141	0.203	0.179

THE FOLLOWING IS A MONTHLY SUMMARY OF WATER YIELDS 1962:

MONTH	RAIN+ MELT	ET	EVAP	RUNOFF	RETURN FLOW ONSITE	RETURN FLOW OFFSITE	GR
1	1.750	0.574	0.001	0.001	0.001	0.0	0.0
2	3.469	0.347	0.005	0.032	0.002	0.0	0.0
3	3.498	0.142	0.006	0.298	0.224	0.0	0.099
4	1.528	0.112	0.000	0.661	0.661	0.0	0.777
5	1.169	0.212	0.000	0.281	0.281	0.0	0.652
6	3.759	0.631	0.027	1.956	1.829	0.0	1.112
7	1.670	2.416	0.004	0.070	0.069	0.0	0.280
8	2.110	1.132	0.000	0.060	0.060	0.0	0.144
9	0.560	2.977	0.0	0.0	0.0	0.0	0.0
10	0.380	3.195	0.0	0.0	0.0	0.0	0.0
11	0.610	1.932	0.0	0.0	0.0	0.0	0.0
12	1.700	1.066	0.016	0.004	0.0	0.0	0.0
TOTAL	22.205	14.737	0.060	3.363	3.127	0.0	3.064

	ZONE 1				ZONE 2				ZONE 3			
	RETURN FLOW				RETURN FLOW				RETURN FLOW			
MO	QO	ONSITE	OFFSITE	GR	QO	ONSITE	OFFSITE	GR	QO	ONSITE	OFFSITE	GR
1	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0
2	0.03	0.03	0.0	0.0	0.20	0.0	0.0	0.0	0.09	0.02	0.0	0.0
3	0.01	0.15	0.0	0.03	0.00	2.07	0.0	0.32	0.74	2.58	0.0	0.75
4	0.0	0.71	0.0	0.74	0.0	1.05	0.0	0.28	0.0	7.60	0.0	1.23
5	0.0	0.30	0.0	0.62	0.0	0.64	0.0	0.26	0.0	3.23	0.0	1.08
6	0.00	2.02	0.0	1.09	0.00	2.68	0.0	0.51	1.44	21.02	0.0	1.41
7	0.0	0.08	0.0	0.25	0.0	0.18	0.0	0.07	0.0	0.80	0.0	0.68
8	0.0	0.03	0.0	0.10	0.0	0.55	0.0	0.21	0.0	0.69	0.0	0.57
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0
TOTAL	0.05	3.32	0.0	2.83	0.20	7.18	0.0	1.64	2.28	35.94	0.0	5.71

THE FOLLOWING ARE SA VALUES IN INCHES AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

ZONE=	1	1.5009	11.6732	0.1460	0.6250
ZONE=	2	1.5529	9.7860	0.1460	0.6250
ZONE=	3	1.6537	10.9260	0.1460	0.6250

THE FOLLOWING ARE RE-START VALUES TO APPROXIMATE WATERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

INITIAL STREAM FLO= 0.0

ZONE	% ASM1	% ASM2
1	19.224	9.671
2	18.645	12.667
3	17.525	10.857

RAIN-ET-RUNOFF-E-CN-SOIL-CHANNEL-DEPRESSIONS-OVERLAND-OFFSITE= -0.007
22.205 14.737 3.363 0.060 3.064 0.988 0.0 0.0 0.0 0.0

SNOW= 0.015

STATISTICS

SUM OF OBSERVED = 0.20256643E 01 SUM OF SQUARE OF OBSERVED = 0.12331319E 00
SUM OF PREDICTED = 0.33630066E 01 SUM OF SQUARE OF PREDICTED = 0.46493298E 00
MEAN OF OBSERVED = 0.55346005E-02 MEAN OF PREDICTED = 0.91885403E-02

CORRELATION COEFFICIENT = 0.0
STANDARD DEVIATION = 0.22300187E-01
COVARIANCE = 0.40292311E 01

LAND USE FOR YEAR 1963 FOLLOWS. IF A ZONE IS NOT MENTIONED, VALUES OF PREVIOUS YEAR ARE ASSUMED.

ZONE 1	WINWHEAT = 39.3%	SPGRAIN = 10.7%	PEAS = 35.8%	CLOVER = 0.0%	ALFALFA = 0.0%	PASTURE = 3.3%
	WOOD = 2.0%	MISC = 3.9%	FALLOW = 5.0%			
ZONE 2	WINWHEAT = 0.0%	SPGRAIN = 0.0%	PEAS = 0.0%	CLOVER = 100.0%	ALFALFA = 0.0%	PASTURE = 0.0%
	WOOD = 0.0%	MISC = 0.0%	FALLOW = 0.0%			
ZONE 3	WINWHEAT = 81.4%	SPGRAIN = 0.0%	PEAS = 0.0%	CLOVER = 0.0%	ALFALFA = 0.0%	PASTURE = 14.7%
	WOOD = 0.0%	MISC = 0.0%	FALLOW = 3.7%			

PAN EVAPORATION FOR YEAR 1963 FOLLOWS.

WEEK 1	0.114	0.097	0.080	0.063
WEEK 5	0.042	0.042	0.042	0.042
WEEK 9	0.042	0.016	0.016	0.016
WEEK 13	0.016	0.016	0.016	0.016
WEEK 17	0.016	0.027	0.027	0.027
WEEK 21	0.027	0.065	0.065	0.065
WEEK 25	0.065	0.065	0.066	0.113
WEEK 29	0.092	0.126	0.139	0.120
WEEK 33	0.213	0.274	0.219	0.083
WEEK 37	0.171	0.274	0.201	0.280
WEEK 41	0.249	0.239	0.267	0.316
WEEK 45	0.259	0.353	0.210	0.240
WEEK 49	0.236	0.254	0.166	0.174

THE FOLLOWING IS A MONTHLY SUMMARY OF WATER YIELDS 1963:

MONTH	RAIN+ MELT	ET	EVAP	RUNOFF	RETURN FLOW ONSITE	RETURN FLOW OFFSITE	GF
1	3.320	0.677	0.026	0.003	0.000	0.0	0.0
2	2.500	0.425	0.002	0.001	0.001	0.0	0.000
3	2.070	0.171	0.004	0.140	0.122	0.0	0.207
4	0.460	0.072	0.000	0.106	0.106	0.0	0.302
5	3.489	0.325	0.015	2.074	1.459	0.0	1.081
6	2.090	0.701	0.013	0.540	0.318	0.0	0.207
7	1.789	1.548	0.010	0.594	0.549	0.0	0.847
8	0.450	2.118	0.0	0.0	0.0	0.0	0.0
9	2.720	2.677	0.020	0.456	0.0	0.0	0.0
10	0.370	3.092	0.0	0.0	0.0	0.0	0.0
11	0.430	1.959	0.0	0.0	0.0	0.0	0.0
12	1.030	1.088	0.0	0.0	0.0	0.0	0.0
TOTAL	20.717	14.852	0.090	3.914	2.555	0.0	2.644

	ZONE 1				ZONE 2				ZONE 3			
	RETURN FLOW				RETURN FLOW				RETURN FLOW			
MO	QO	ONSITE	OFFSITE	GR	QO	ONSITE	OFFSITE	GR	QO	ONSITE	OFFSITE	GR
1	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0
2	0.0	0.02	0.0	0.0	0.0	0.14	0.0	0.02	0.00	0.01	0.0	0.0
3	0.0	0.08	0.0	0.13	0.0	1.51	0.0	0.38	0.21	1.40	0.0	0.93
4	0.0	0.12	0.0	0.29	0.0	0.30	0.0	0.10	0.0	1.22	0.0	0.48
5	0.01	2.10	0.0	1.05	0.0	2.87	0.0	0.38	6.95	16.77	0.0	1.54
6	0.0	0.70	0.0	0.20	0.0	1.25	0.0	0.17	2.62	3.65	0.0	0.24
7	0.0	0.46	0.0	0.81	0.0	0.75	0.0	0.24	0.45	6.31	0.0	1.31
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.46	0.0	0.0	0.0	4.62	0.0	0.0	0.0	1.00	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	0.47	3.48	0.0	2.49	4.62	6.82	0.0	1.29	11.23	29.37	0.0	4.50

THE FOLLOWING ARE SA VALUES IN INCHES AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

ZONE=	1	2.0628	11.9105	0.1460	0.6250
ZONE=	2	2.2182	9.7860	0.1460	0.6250
ZONE=	3	2.2203	10.9260	0.1460	0.6250

THE FOLLOWING ARE RE-START VALUES TO APPROXIMATE WATERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY WAS PRINTED:

INITIAL STREAM FLO= 0.0

ZONE	% ASM1	% ASM2
1	12.980	9.295
2	11.253	12.667
3	11.229	10.857

RAIN-ET-RUNOFF-E-CN-SOIL-CHANNEL-DEPRESSIONS-OVERLAND-OFFSITE= -0.006
20.717 14.852 3.914 0.090 2.644 -0.777 0.0 0.0 0.0 0.0

SNOW= 0.003

STATISTICS

SUM OF OBSERVED = 0.21545353E 01 SUM OF SQUARE OF OBSERVED = 0.58002990E 00
SUM OF PREDICTED = 0.39136887E 01 SUM OF SQUARE OF PREDICTED = 0.10086546E 01
MEAN OF OBSERVED = 0.58867075E-02 MEAN OF PREDICTED = 0.10693137E-01

CORRELATION COEFFICIENT = 0.37707764E 00
STANDARD DEVIATION = 0.36465310E-01
COVARIANCE = 0.61945162E 01