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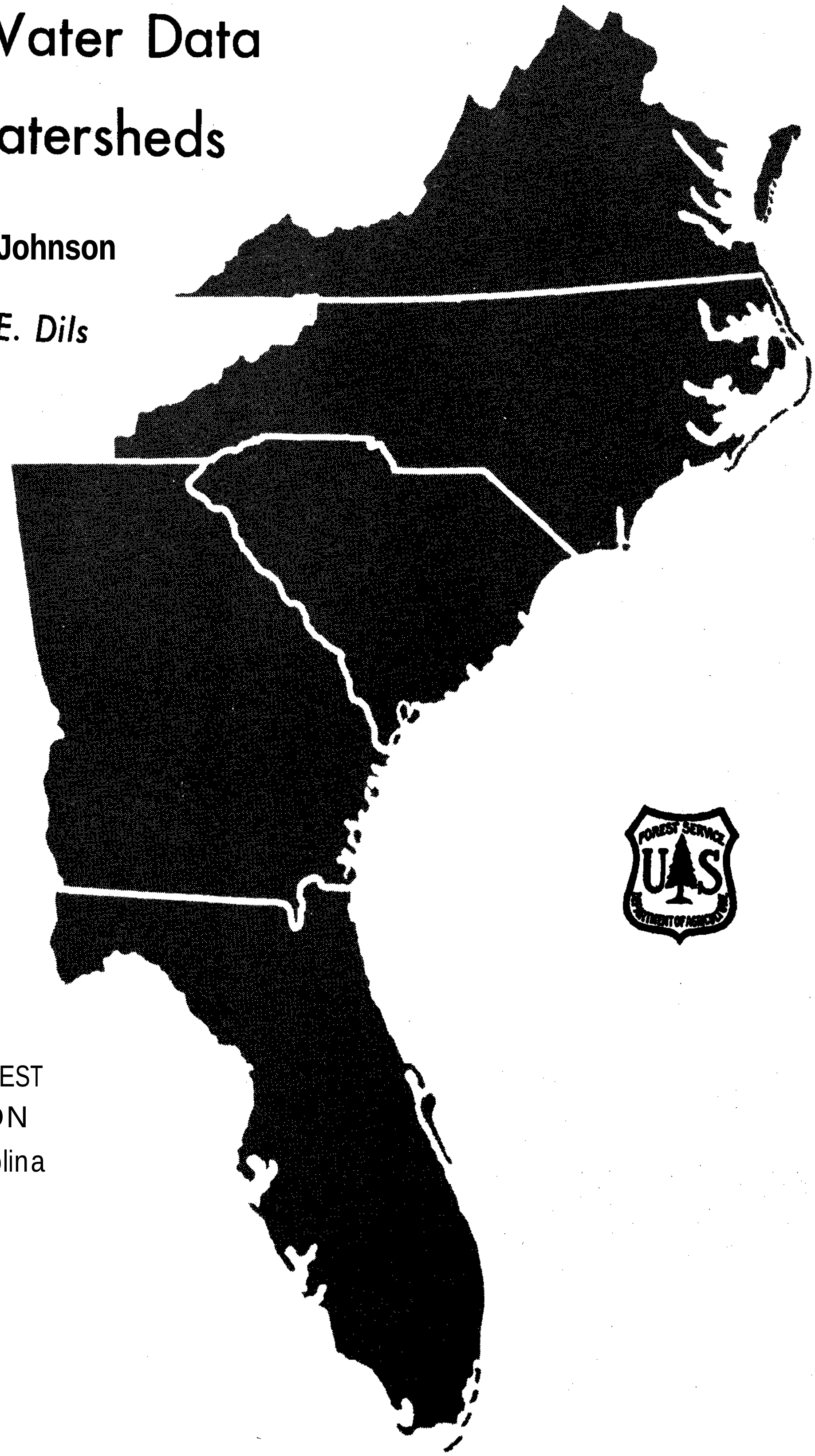
Outline for Compiling Precipitation, Runoff, and Ground Water Data from Small Watersheds

by Edward A. Johnson

and Robert E. Dils



SOUTHEASTERN FOREST
EXPERIMENT STATION
Asheville, North Carolina

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

This is a revision of Technical Note No. 34, first.issued in 1938 by C. R. Hursh. Reissues in 1939 and 1940 included numerous valuable suggestions for improvements from co-workers in the field of small drainage-area studies. Since the last issue in 1940, additions and deletions in both procedures' and forms have been effected. In the present edition these changes have been brought up to date and more recent techniques and methods added; also a new section in. ground water inventories.

This outline represents the efforts of the field and office staffs and technicians of the Division of Watershed Management at the Southeastern Forest Experiment Station, and acknowledgment is made to all who have been associated with this Division.

ABBREVIATIONS

c.f.	=	cubic feet
c.f.s.	=	cubic feet per second
c.s.m.	=	cubic feet per second per square mile
gal.	=	gallons
gpd.	=	gallons per day
mgd.	=	million gallons per day
a./f.	=	acre feet
in. /hr.	=	inches per hour

WATER UNITS

1 cubic foot = 7.4805 gallons
1 acre foot = 43,560 cubic feet
1 acre foot = 325,851 gallons
1 acre inch = 3,630 cubic feet
1 acre inch = 27,154 gallons

1 cubic foot per second = 646,317 gpd.
1 cubic foot per second per day = 1.9835 a. /f.
1 gallon per minute = 1440 gpd.
1 million gallons per day = 1.5472 c. f. s.

CONTENTS

OUTLINE FOR COMPILING PRECIPITATION, RUNOFF, AND GROUND WATER DATA FROM SMALL DRAINAGE AREAS

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INTRODUCTION

Studies of small drainage areas directed toward a better understanding of the relationships between land management practices and water resources are among the best bases for intelligent management of water once it falls on the land as precipitation. Information derived from such studies serves as a basis upon which to plan for water conservation, and for agricultural, municipal, industrial, and recreational needs.

Before any resource can be managed properly, an inventory is necessary. A complete inventory or accounting for all forms of water recharge and water discharge for any drainage area would require a thorough analysis of all phases of the hydrologic cycle including precipitation losses due to interception by vegetative canopies, evaporation and transpiration losses, soil moisture retention, and all forms of ground water seepage. Many years of systematic research will be required before all these phases of the hydrologic cycle will be accounted for accurately. Fortunately, certain of the more easily measured phases do furnish a fairly reliable basis for interpreting important trends in the water economy of small drainage areas. Three such measurements are precipitation, runoff or streamflow, and ground water storage. These measurements are the primary steps in studies of small drainage areas. They also assist in orienting the research needs for other less easily measured phases of the hydrologic cycle.

This outline describes a basic inventory method for the systematic compilation of data on precipitation, streamflow, and ground water. It is based on over 20 years of experience with small drainage areas at the Coweeta Hydrologic Laboratory, in the Southern Appalachian Mountains. As an aid in subsequent analysis work, much of the data is compiled to correspond with the growing and dormant seasons, i. e . , from May to October and November to April, respectively, or to correspond with the following hydrologic seasons:

May-September, period of maximum evaporation and transpiration;
October-December, period of soil moisture recharge;
January-April, period of ground water recharge.

PRECIPITATION

Since approximately 98 percent of the precipitation received on the Coweeta Hydrologic Laboratory occurs in the form of rain, the treatment of precipitation in this paper is restricted to the compilation of rainfall data.

Two measurements of rainfall are commonly made in hydrologic as well as meteorologic studies: first, total rainfall, in which the U. S. Weather Bureau standard rain gage is used, and second, rainfall intensity, where a recording gage is used.

STANDARD RAIN GAGE DATA

Trail Forms a and b

The original field measurements of rainfall collected in the standard rain gages are tabulated on Trail Form a. In addition to the depth of rain in inches, the rain gage number, date of rain, date of the gage reading, time of the reading, and any pertinent remarks are all recorded on the trail form. The original field or trail forms are filed for permanent reference.

For major storms, or all storms yielding over 2 inches of rain, a supplemental form, Trail Form b, is used along with Trail Form a. On line 1, the gage number is entered. On line 2, a check measurement is entered. This consists of the stick reading in inches and hundredths of inches in the 8-inch cylinder after the full 2-inch core has been removed. On line 3, 2.00 inches is ordinarily entered for the volume of water in the full 2-inch core. The water in this core is thrown out and the core is filled nearly full from the water remaining in the 8-inch cylinder. This volume is measured and the value recorded on line 4. If more water remains, the process is repeated and the volume recorded on line 5. The column is then totaled (starting with line 3). This total is entered on line 6 and also in the appropriate column on Trail Form a. If more than 6 inches of rain is measured, use another column to record the values on Trail Form b.

Storm Separation

It is not always practicable to read each standard rain gage immediately after a storm, and quite often a second storm occurs before a measurement can be made. For individual storm studies it is then necessary to separate the amount of rainfall attributed to each storm. To make such separations, the chart from the recording rain gage nearest to a standard gage is examined and the amount of rainfall attributed to each storm is calculated. The percentage of rainfall for each storm is computed, and these percentages are then applied to the standard gage readings. Data at the head of page 4 illustrate this method of storm separation.

Trail Form a

U. S. Department of Agriculture   Trail Form a
Forest Service
Experimental Area Coweeta
RI-SE
Water Relations   Name of Trail Wildcat
Precipitation

Gage No.	Date of rain	Date of reading	Time of reading	Reading (Inches)	Observer initials	Remarks
14	3/10-11/52	3/11/52	0920	5.72	JS	See Trail Form b
39				5.56		
50				4.92		
69				4.98		
7				7.20		
8				6.51		
9				6.67		
12				4.26		
18				4.63		
20				5.40		
21				4.66		
25				4.15		

Trail Form b

U. S. Department of Agriculture   Trail Form b
Forest Service
Experimental Area Coweeta
RI-SE
WATER RELATIONS   Name of Trail Wildcat
Precipitation

Gage No.	(1)	14	39	50	69	7	8	9	12	18
Check	(2)	3.70	3.60	2.90	3.00	5.10	4.50	4.65		
2" core	(3)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Refill-1	(4)	1.95	1.90	1.97	1.93	1.90	1.95	1.89	1.94	1.90
Refill-2	(5)	1.77	1.66	.95	1.05	1.92	1.96	1.96	.32	.73
Total	(6)	5.72	5.56	4.92	4.98	-	-	-	4.26	4.63
Gage No.	(1)	20	21	25		7	8	9		
Check	(2)					-	-	-		
2" core	(3)	2.00	2.00	2.00		-	-	-		
Refill-1	(4)	1.94	1.95	1.97		1.38	.60	.82		
Refill-2	(5)	1.46	.71	.18		-	-	-		
Total	(6)	5.40	4.66	4.15		7.20	6.51	6.67		
Gage No.	(1)									
Check	(2)									
2" core	(3)									
Refill-1	(4)									
Refill-2	(5)									
Total	(6)									

Storm	Recording rain gage values	Percentages	Standard rain gage values No. 21	No. 20	No. 18
	Inches		Inches	Inches	Inches
Total	5.40	100	5.38	5.50	5.27
Storm 1	1.65	30.6	1.65	1.68	1.61
Storm 2	3.75	69.4	3.73	3.82	3.66

Monthly Record of Standard Rain Gages--Form 1

The next step in the compilation of standard rain gage data is to summarize individual storm values by months. Rainfall data for each gage and for each storm are entered on Form 1, which shows the dates rainfall occurred, the corresponding dates on which the gages were read and the amount of rain recorded in inches. The rainfall columns are totaled to give the total monthly rainfall for each gage. If the individual storm values were derived by storm separation rather than directly from the trail form, this is indicated in the remarks column.

Annual Summary of Standard Rain Gage Data by Months

Another step in the recording of data from the individual standard rain gages is the annual summary by months (see following summary). Supplemental information in addition to the actual rainfall data by months and years might be the elevation at the gage location, the rise in feet from the gage location to the top of the ridge, the azimuth of the exposure, and the slope distance from the gage location to the top of the ridge, as well as the recording rain gage used for storm separations, and the watersheds which the gage services.

Record of Weighted Mean Precipitation on an Individual Drainage Basin

Since most drainages require more than one gage for adequate sampling, precipitation in area inches is derived from a weighted mean of all gage measurements. Form 2 is used for this computation.

The Horton- Thiessen Mean Method [1/] is ordinarily used for estimating the weighted area inches of rainfall. This method consists of applying to each standard gage reading a weight factor which is the percentage of the total drainage area lying closer to this gage than to any other gage. The rain gage service area, represented by each standard rain gage, is determined by geometric construction and planimetering. Each rain gage reading is applied to an area bounded by either the perpendicular bisectors of the lines connecting each gage to adjacent gages, or by the boundary of the drainage area, or by both. Figure 1 illustrates the method of determining rain gage service areas.

1/ Horton, Robert E. Accuracy of area1 rainfall estimates. Monthly Weather Review 51: 348-353. 1923.

FU-SE!
WATER RELATIONS
Precipitation
Experimental Area Coweeta

U. S. Department of Agriculture
Forest Service
MONTHLY RECORD OF STANDARD RAIN GAGES

Form 1
File lo. 3.131

Date		Rain gage number												Remarks
Read	Rain of	14	39	50	69	7	8	9	12	18	20	21	25	
3/4	2,3,4	2.70	2.46	2.43	2.73	2.96	3.16	2.80	2.42	2.45	2.56	2.54	2.46	
3/11	10, 11	5.72	5.56	4.92	4.98	7.20	6.51	6.67	4.26	4.63	5.40	4.66	4.15	
3/19	18, 19	1.82	1.71	1.50	1.61	2.13	2.12	1.95	1.47	1.52	1.69	1.45	1.33	
3/23	21	1.70	1.54	1.56	1.78	1.68	1.94	1.81	1.53	1.61	1.68	1.63	1.48	*
3/23	22, 23	4.40	3.98	4.02	4.61	4.07	4.69	4.88	3.51	3.66	3.82	3.75	3.42	*
3/25	23	.17	.22	.16	.17	.15	.18	.20	.19	.18	.17	.17	.17	*
3/25	24	.21	.27	.20	.21	.28	.34	.38	.29	.23	.22	.26	.26	*
4/2	31	.22	.19	.20	.27	.33	.37	.37	.16	.23	.23	.17	.17	
Monthly totals		16.94	15.93	4.99	16.36	18.80	19.31	19.06	13.83	14.51	15.77	4.63	13.44	

asterisk indicates all storms determined by storm separation

Month March Year 1952

Sheet 1 of 1

Recorder C. L. Shope

File No. 3.134

RI-SE
WATER RELATIONS
Precipitation
Expt. Area Coweetn

U. S. Department of Agriculture
Forest Service
ANNUAL RECORD BY MONTHS FOR AN
INDIVIDUAL STANDARD RAIN GAGE

(In inches)

Standard Rain Gage No. 39

Computed by B.C.
Checked by E.A.J.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Mean
1935	7.70	3.81	5.79	6.16	4.09	3.58	8.65	10.58	1.31	2.57	8.06	6.34	68.64	
1936	14.50	9.45	6.59	10.46	2.56	2.94	7.36	6.57	8.85	5.02	2.04	12.39	88.73	
1937	12.43	6.35	3.10	7.76	2.27	5.53	3.92	4.73	2.83	9.14	2.86	6.30	67.22	
1938	5.03	2.76	9.83	5.27	6.39	6.89	12.18	1.75	3.32	.16	11.60	3.26	68.44	
1939	4.41	12.63	7.90	5.31	3.03	3.38	6.36	6.23	1.10	.92	.83	3.92	56.02	
1940	2.96	7.38	5.28	7.31	2.36	7.26	4.20	13.89	.91	1.90	5.91	4.86	64.22	
1941	3.44	1.64	5.45	3.51	1.41	3.27	10.35	3.43	3.40	2.92	4.69	8.61	52.12	
1942	5.32	6.33	9.35	1.00	9.71	3.40	9.80	4.05	6.48	3.58	2.68	13.00	74.70	
1943	7.41	5.04	9.41	6.17	4.13	6.48	11.86	5.10	5.26	2.64	2.44	4.36	70.30	
1944	4.54	12.03	12.46	6.87	4.73	1.47	3.91	6.44	7.56	1.15	5.74	7.39	74.29	
1945	2.62	8.22	[illegible].73	8.44	3.20	7.11	3.45	3.64	4.74	5.07	4.80	8.59	165.07	
1946	12.69	8.07	5.53	5.94	8.36	3.36	5.01	3.76	3.21	4.44	4.131	4.93	75.50	
1947	12.40	2.86	11.70	2.54	4.57	5.02	3.56	6.47		7.89	6.71	4.31	68.03	
1948	5.88	8.75			6.15	4.40	9.60	8.26	3.95	1.19	19.51	7.42	87.73	
1949	9.46	6.72	6.76	8.18		10.38	8.93	9.00	5.44	10.23	2.591	7.13	190.94	
1950	5.82	8.21	7.39	2.39	5.12	5.00	7.60	10.97	6.26	5.94	2.06	5.98	72.74	
1951	4.00	5.44	7.90	5.57	.98	11.19	7.78	1.61	5.67	4.86	4.24	12.48	71.72	
1952	6.77	5.12	15.93	4.78	3.47	5.16	1.94	5.74	3.58	1.29	5.97	6.88	66.63	
1953	8.83	10.14	5.84	4.34	3.19	7.07	4.57	2.77	4.99	1.09	4.53	10.06	67.42	
1954	12.03	6.53	8.44	5.11	3.57	4.20	6.83	2.94	.40	.82	.84	10.24	65.95	

R. R. G. 2 for storm separation
Watershed 18 and 9

Sheet 1 of 1 sheets

RI-SE
WATER RELATIONS
Precipitation
Expt. Area Coweeta

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

PRECIPITATION ON INDIVIDUAL WATERSHEDS

Form2
File No. 3.132

Watershed Area 1455 acres

Gage Reader C.S. Recorded by H.K.S. Date Computed by A.C. Date

Rain Gage No. (1)	Weight Factor* (2)	Sept. 3 Gage Reading (3)	Sept. 3 Reading x Factor (4)	Sept. 12-15 Gage Reading (5)	Sept. 12-15 Reading x Factor (6)	Sept. 20 Gage Reading (7)	Sept. 20 Reading x Factor (8)	Sept. 24 Gage Reading (9)	Sept. 24 Reading x Factor (10)	Sept. 29 Gage Reading (11)	Sept. 29 Reading x Factor (12)	Sept. 29-30 Gage Reading (13)	Sept. 29-30 Reading x Factor (14)	Oct. 5-8 Gage Reading (15)	Oct. 5-8 Reading x Factor (16)	Gage Reading (17)	Reading x Factor (18)
No.	Pct.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.		
12	19	1.10	0.21	0.12	0.02	1.80	0.34	0.49	0.09	0.35	0.07	5.94	1.13	0.88	0.17		
18	19	1.21	0.23	0.12	0.02	2.00	0.38	0.57	0.11	0.37	0.07	6.08	1.16	0.73	0.14		
20	11	1.26	0.14	0.25	0.03	1.88	0.21	0.61	0.07	0.44	0.05	5.94	0.65	0.83	0.09		
21	49	1.21	0.59	0.16	0.08	1.85	0.91	0.60	0.29	0.44	0.22	5.90	2.89	0.92	0.45		
25	2	1.11	0.02	0.34	0.01	1.40	0.03	0.56	0.01	0.41	0.01	5.30	0.11	1.15	0.02		
Total (Inches)			1.19		0.16		1.87		0.57		0.42		5.94		0.87		

* Where Thiessen Method is used

Period September 3 to October 8, 1936

Sheet 1 of 1 Sheets

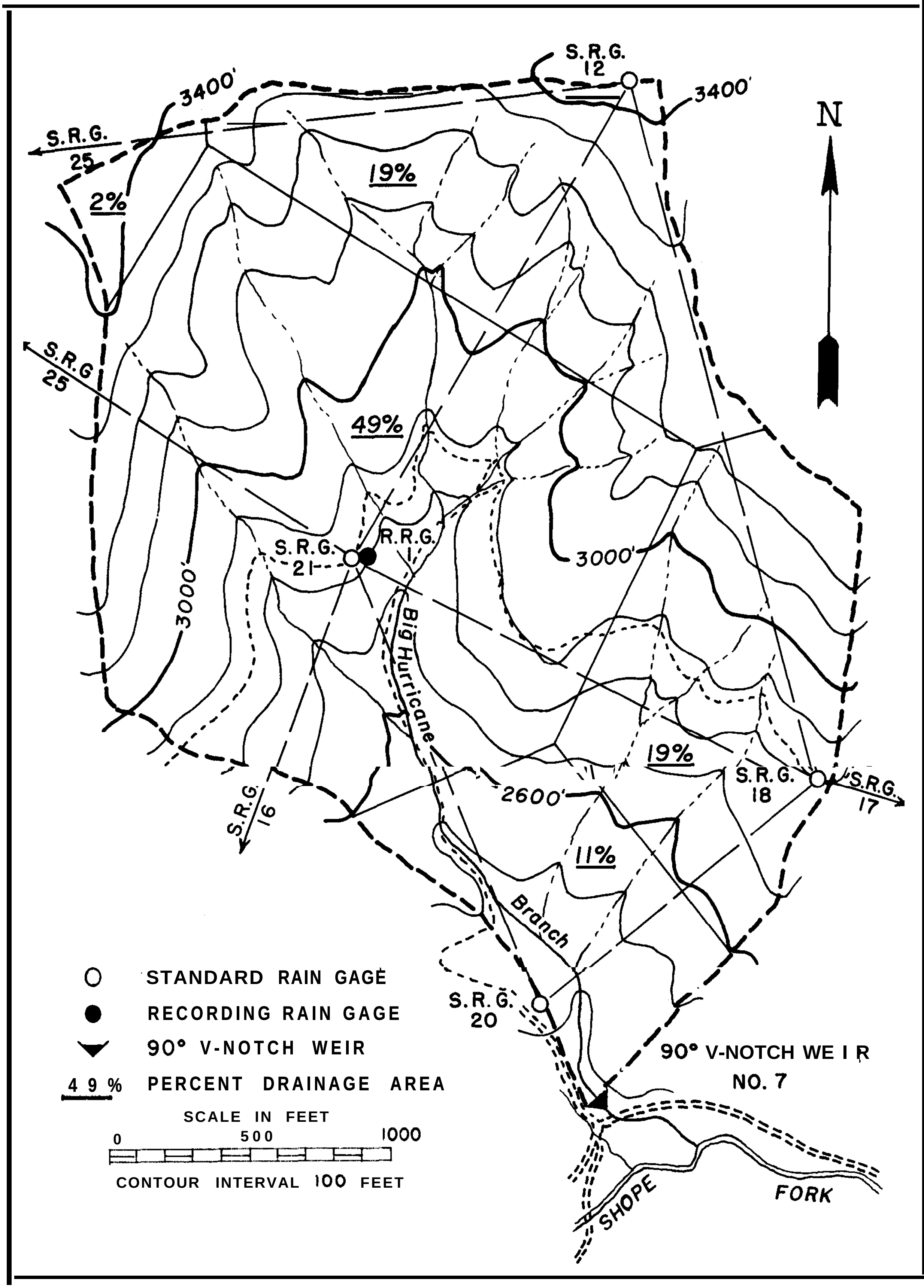

Figure 1. --Rain gage service areas for Watershed 7, a 145.5-acre area.

The standard rain gage (S.R.G.) number and its weight factor are listed in the first and second columns of Form 2. In the remaining 14 columns are recorded individual storms, each storm requiring two columns. The amount of precipitation for each gage is recorded in the first column, the product of the weight factor and the amount of precipitation in the second. The sum of the amounts in the second column is the weighted mean precipitation on the drainage basin in area inches for the individual storms.

This method is ordinarily employed for routine weighted rainfall compilations. However, for special investigations it may be desirable to use other methods such as plotting rainfall isohyetols.

Summary of Weighted Precipitation for Drainage Areas

To complete the summarization of "raw" precipitation data, a summary of the weighted precipitation received on a given watershed is tabulated by months and years. An example of such a tabulation is shown in the Annual Record of Weighted Precipitation below (File No. 3.1321) for Coweeta Watershed No. 18. Note the supplemental data.describing elevation, area, recording gage, and standard gages.

RECORDING RAIN GAGE DATA

For most hydrologic work, it is desirable to know not only the total amount of rainfall or recharge but also the manner in which it was received, i.e., the rainfall intensities. Three types of instruments have been used for recording rainfall: the weighing gage, the float gage, and the tipping bucket gage. Only the first of these is commonly used today; however, the method of recording is similar in the first two and this discussion would apply to either type. Rainfall intensities are recorded on the precipitation intensity record, Form 4.

Precipitation Intensity Record- -Form 4

On this form is shown a continuous record of rainfall for individual storms as recorded by a single recording rain gage, and also as corrected for the rainfall collected in a standard rain gage, which in each case is installed beside the recording gage. The purpose of this form is to tabulate data for an accurate reproduction of recorded precipitation and to compile precipitation intensity data.

A storm is considered as a period of precipitation separated by at least 6 hours from any other period in which precipitation occurs. The times of beginning and ending of the precipitation are indicated on the recorded chart by the symbols, P. B. and P. **E.,** respectively (fig. 2).

Column 1. Date of rainfall.

Column 2. Time of change in rainfall intensity. The time is read from the recorder chart at the points where significant changes in rainfall rates occur. Such points are called natural breaks.

RI-SE
WATER RELATIONS
Precipitation
Expt. Area Coweeta

File No. 3.1321

U. S. Department of Agriculture
Forest Service
ANNUAL RECORD BY MONTHS OF WEIGHTED
PRECIPITATION ON AN INDIVIDUAL DRAINAGE BASIN

(In inches)

Watershed No. 18

Computed by B.C.
Checked by E.A.J.

Water year	Total	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.
1935													
1936										7.40	6.79	8.93	5.08
1937	73.20	2.04	12.32	12.60	6.43	3.10	7.89	2.30	5.61	3.97	4.77	2.87	9.30
1938	65.62	2.93	6.86	4.95	2.84	8.97	6.22	6.43	6.94	11.99	3.80	3.53	.16
1939	75.09	11.67	3.33	8.07	16.45	8.20	5.42	3.67	3.44	6.12	6.66	1.15	.91
1940	60.14	.85	4.07	3.39	7.56	5.62	7.74	2.21	7.46	4.34	14.06	.92	1.92
1941	49.73	5.73	5.18	3.61	1.62	5.45	3.50	1.38	3.24	10.54	3.22	3.43	2.83
1942	73.11	4.61	8.41	5.30	6.90	9.81	1.00	9.84	3.34	9.84	4.09	6.39	3.58
1943	78.80	2.65	13.04	7.05	5.16	9.39	6.03	4.16	6.48	11.75	5.06	5.32	2.71
1944	68.14	2.46	4.41	4.56	12.19	12.49	6.75	4.63	1.45	3.89	6.52	7.64	1.15
1945	65.72	5.94	7.50	2.60	8.36	5.78	8.45	3.24	3.06	3.54	3.68	8.42	5.15
1946	79.49	4.87	8.56	12.72	8.03	11.06	4.83	8.44	3.18	4.96	3.54	4.84	4.46
1947	66.05	4.22	5.01	12.33	2.84	5.57	5.83	4.09	5.02	3.72	6.33	3.22	7.87
1948	71.46	6.68	4.31	5.83	8.87	11.54	2.42	4.57	4.35	9.59	8.16	3.97	1.17
1949	107.24	19.15	7.41	9.58	6.81	6.64	8.09	6.02	10.37	8.58	8.91	5.44	10.24
1950	73.91	2.56	7.20	5.97	8.17	7.32	2.40	4.95	4.87	7.49	10.79	6.08	6.11
1951	62.09	2.07	5.78	3.98	5.35	7.77	5.48	.97	11.10	7.36	1.53	5.76	4.94
1952	70.15	4.20	12.66	7.06	5.09	15.60	4.75	3.43	5.02	1.89	5.61	3.53	1.31
1953	65.34	5.97	6.90	8.86	10.11	5.80	4.34	3.08	6.98	4.45	2.85	4.92	1.08
1954	70.19	4.47	9.95	12.19	6.44	12.70	5.09	3.58	4.78	6.89	2.86	.39	.85

Watershed Data:
Max. elevation 3258 ft.
Min. elevation 2382 ft.
Mid. elevation 2703 ft.
Area 30.84 acres

RRG for storm separation 2
Standard rain gages 39, 68

Sheet 1 of 1 sheets

RI-SE
WATER RELATIONS
Precipitation

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Form 4
File No 3.133

PRECIPITATION INTENSITY RECORD

Rain Gage No. 1, Type Recording Float
1 Inch on Chart = 1 In. Precip., 80 Min. Time
Time and Date of Storm Sept. 29-30, 1936
(Circle One: EST, CST, MST, PST)
Elevation: (M.S.L.) 2875 Feet

Experimental Area Coweeta
Watershed 7 145.5 A
Lat. °, ', " Long. °, ', "
Sec , Tp. , Range
Total Precipitation 5.94 Inches

Date 1936 (1)	Time Hr. Min. (2)	Time Interval Min. (3)	Depth Recorded In. (4)	Increment Recorded In. (5)	Increment Corrected In. (6)	Rate per Hour Inches per Hr. (7)	Remarks (8)
Sept. 29	1710		.00	.00			P.B. 1710
	1715	5	.07	.07	.07	0.84	
	1725	10	.27	.20	.20	1.20	
	1740	15	.31	.04	.04	0.16	
	1830	50	.32	.01	.01	0.01	
	1850	20	.36	.04	.04	0.12	
	2020	90	.69	.33	.33	0.22	
	2050	30	.76	.07	.07	0.14	
	2100	10	.92	.16	.16	0.96	
	2105	5	1.07	.15	.15	1.80	
	2120	15	1.49	.42	.41	1.64	
	2130	10	1.72	.23	.23	1.38	
	2145	15	1.87	.15	.15	0.60	
	2150	5	2.05	.18	.18	2.16	
	2155	5	2.27	.22	.22	2.64	
	2200	5	2.35	.08	.08	0.96	
	2240	40	2.63	.28	.28	0.42	
	2310	30	2.93	.30	.30	0.60	
	2320	10	3.20	.27	.27	1.62	
	2340	20	3.50	.30	.30	0.90	
	2350	10	3.87	.37	.37	2.22	
	2355	5	4.12	.25	.25	3.00	
	2400	5	4.40	.28	.28	3.36	
Sept. 30	0030	30	4.57	.17	.17	0.34	
	0100	30	4.66	.09	.09	0.18	
	0200	60	4.80	.14	.14	0.14	
	0220	20	4.90	.10	.10	0.30	
	0245	25	5.22	.32	.32	0.77	
	0325	40	5.47	.25	.25	0.38	
	0340	15	5.68	.21	.21	0.84	
	0350	10	5.71	.03	.03	0.18	
	0410	20	5.72	.01	.01	0.03	
	0420	10	5.89	.17	.17	1.02	
	0430	10	5.94	.05	.05	0.30	
	0600	90	6.02	.08	.08	0.05	P.E. 0600
Totals							

Correction Factor = Mean Basin Precipitation or S.R.G. 5.94 / Recording Rain Gage Precipitation 6.02 = .987 Storm Class

Maximum Depth and Intensity for Given Time Intervals

Duration Min.	2	5	10	15	20	30	60	120	240	6 Hrs.	12 Hrs.
Depth in Inches		0.28	0.52	0.71	0.88	1.04	1.53	2.00	3.75	4.41	5.88
Intensity In./Hr.		3.36	3.12	2.84	2.63	2.09	1.53	1.00	0.94	0.74	0.49

Tabulated by HKS Date June 1938 Checked by K.A.M. Date June 1938
Computed by HKS Date June 1938 Checked by K.A.M. Date June 1938
Period of Record 1710 Sept. 29 to 0410 Sept. 30, 1936 Sheet 1 of 1 Sheets

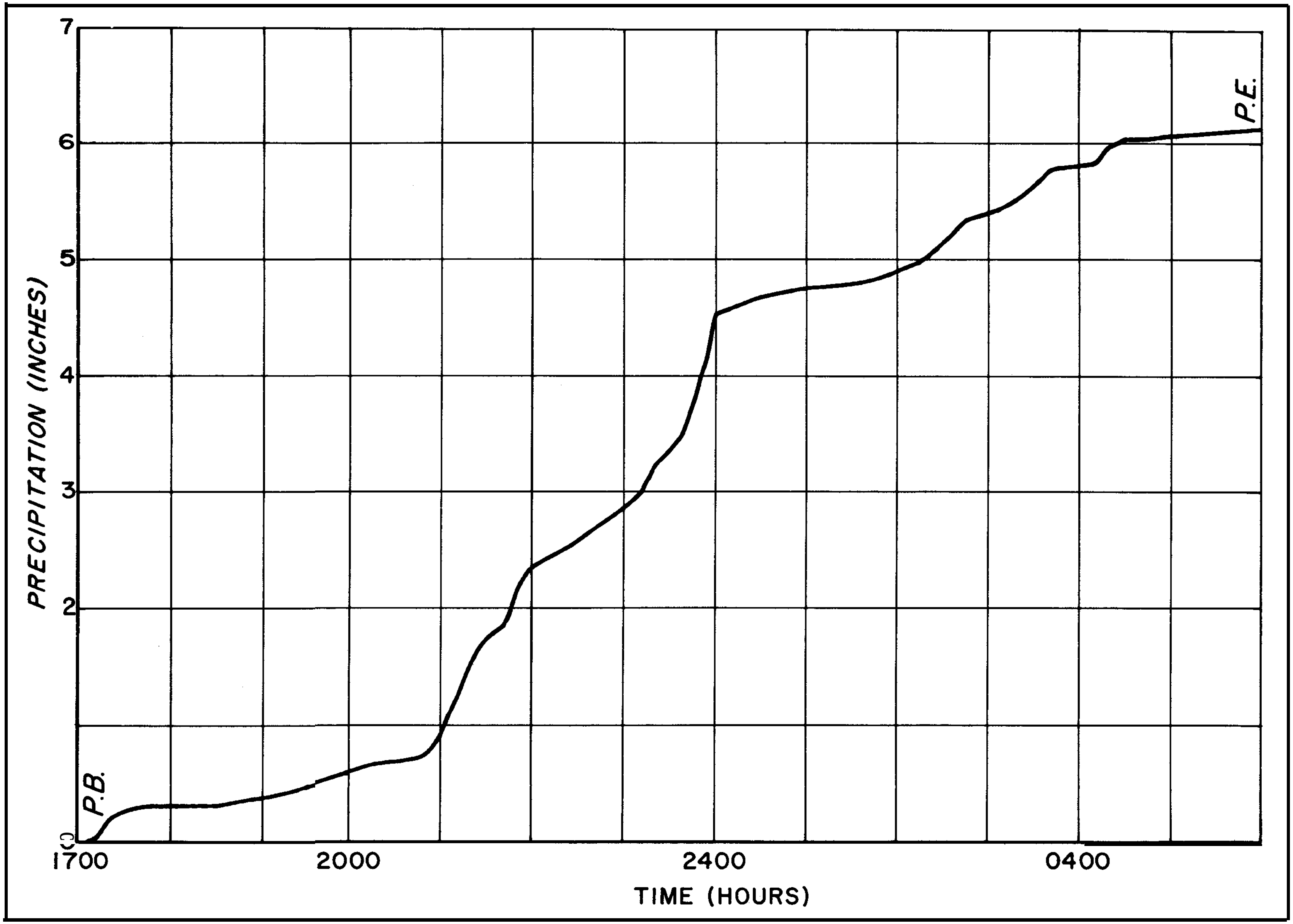

Figure 2.--Mass rainfall curve for storm of September 29-30, 1936, from recording rain gage 1 on Watershed 7.

Column 3. Time intervals in minutes between natural breaks in rainfall intensity are entered here. Intervals are always read to the smallest time interval that can be determined with a reasonable degree of accuracy from the individual recorder chart.

Column 4. Accumulated rainfall or cumulative depths in inches at the end of each time interval are recorded in column 4.

Column 5. The actual increments between intervals are entered here. The first line of the first sheet of a record will be blank.

Column 6. The entries in column 5 are corrected to the standard rain gage catch and entered in column 6. Corrections may be necessary because of instrumental errors, such as pen reversal, base line errors, etc. Depending upon the objective, the mean basin precipitation (weighted area precipitation) may also be used for this correction. The correction factor, as noted on the bottom of the form, is the standard rain gage reading (control rain gage) or the mean basin precipitation value divided by the total recorded rainfall. Figures in column 5 multiplied by this correction factor are the corrected values shown in column 6.

Column 7 The increments of column 6 are converted into rainfall rates in inches per hour for the time interval.

$$\frac{\text{col. } 6 \times 60}{\text{col. } 3} = \text{column } 7$$

Column 8. Notes of beginning and ending of rainfall (P. B. and P. E.) are recorded opposite times shown in column 2. This column is also used for pertinent remarks about the storm or comments concerning the computations. At the bottom of the form, space is provided for recording on the proper lines the figures used in determining the correction factor. The blank provided for storm class may be used for special storm studies. It is not used for routine compilations. The maximum rainfall depths and intensities in inches per hour are recorded for selected rainfall durations in minutes. These rates are obtained by scanning the chart to get the combination producing the maximum rate for each time interval. Note that they are taken directly from the chart and not from the recorded depths. With a little experience these rates can be taken readily from the chart with a template and/or a pair of dividers. Blanks are also provided for dating and initialing the tabulations and checking. In addition, the period of record (dates and times) should be entered at the bottom of the page. Even though no precipitation occurs on some dates, the times and dates from one chart to the next should be continuous to show that no storms have been missed or skipped.

Weighted Rainfall Intensity Records

On larger drainage areas or where intensive sampling is desired on small areas, more than one recording rain gage may be used to service the area. In this case it may be desirable to weight the rainfall intensity data. This may be done by again applying the Horton-Thiessen mean method as outlined previously.

TILTED GAGES

For special studies located in areas of rugged topography with varied wind currents and exposures, it is sometimes desirable to compare precipitation caught in rain gages having orifices set parallel to the slope with the conventional vertically placed gages. Because of differences in the area of the receiver or orifice of the tilted gage exposed to rainfall, it is necessary to correct the tilted-gage values to the equivalent horizontal-gage reading in order to make comparisons between the two settings. The procedure used at the Coweeta Hydrologic Laboratory for making such corrections is given below.

The amount of rainfall in the conventionally placed gage is measured and emptied. Then the volume of rain in the tilted gage is poured into the 2-inch receiver of the standard gage and measured. To correct the latter value, the measured depth in inches is divided by the cosine of the slope angle or the angle of tilt of the tilted gage. Some sample computations are as follows :

Gage number	Field readings: Vertical gage	Field readings: Tilted gage	Cosine θ Correction factor	Corrected tilted-gage reading	Deviation of tilted gage from vertical gage catch	
	Inches	Inches		Inches	Inches	Percent
2	3.70	3.53	.9363	3.77	+.07	2
61	3.93	3.36	.8772	3.83	-.10	3
64	4.33	3.58	.8456	4.13	-.20	5
70	4.10	3.35	.7727	4.33	+.23	6

RUNOFF

The term runoff as used in this paper refers to total discharge and is synonymous with streamflow. Runoff from small drainage areas is ordinarily gaged by measuring the depth of water flowing through a weir. The rise and fall of the water in the weir is recorded on a chart, and by the application of rating tables the runoff may be converted to rates and volumes. Rating table values are usually given in cubic feet per second. The various units in which water is measured and some of the conversion factors that may be applied are given at the beginning and end of this paper.

RECORD OF RUNOFF- -FORM 6

This form is used in computing a continuous record of runoff for an individual drainage basin. Data are broken down into time intervals of such lengths that the records may be used in the analysis of water yield, storm flow, baseflow accretion and depletion, infiltration, and storage or detention. The procedure outlined here is designed to give total water yield. For determining total storm runoff, it is necessary to affix the time of the start and the time of the end of storm runoff and, further, to deduct the base flow or ground water flow. The procedures used in computing the data, however, are similar to those used in computing total water yield.

Form 6 is designed to permit accurate reproduction of the stream hydrograph as well as to give total water yield. To keep the error small, the time intervals are limited by two factors: (1) the curvature of the stage hydrograph and (2) the curvature of the stage-discharge relation. Both factors produce a cumulative error, the net result usually being over-estimated discharges. The error due to curvature of the stage hydrograph is eliminated by breaking the hydrograph into segments which do not have appreciable curvature, while the error due to curvature of the stage-discharge relation is reduced by breaking the hydrograph into short intervals.

Figure 3 illustrates some of the features explained below in connection with the execution of Form 6.

Top of form. The station designation, date of rating table applied, and integrator setting should be indicated in the proper blanks. A complete station description, including name, location, size, elevation, gage type, type of recording instrument, etc., should be available for each station.

Column 1. The date is inserted here.

Column 2. The time of day at which the hydrograph is broken is recorded in hours and minutes to the nearest number of minutes that can be read accurately from the given chart (e.g., 2, 5, 10 or 15). A break in the hydrograph is always made at midnight, at all peaks, at all troughs, and at definite changes in the slope of the hydrograph. In listing the times, a line is left blank after midnight and, where the time of beginning and ending of stormflow is indicated, lines are left blank preceding the start of stormflow and after the end of stormflow.

Column 3. The time intervals in minutes between successive breaks (or between the times of column 2) of the hydrograph are tabulated.

Column 4. Gage heights at the breaks of the hydrograph (or at the times shown in column 2) are read from the hydrograph and recorded in column 4.

RI-SE
WATER RELATIONS
Streamflow
Water Yield

U. S. Department of Agriculture
Forest Service

RECORD OF RUNOFF

Form 6
File No. 3.2211

Expt. Area COWEETA
Station designation No. 7

Discharge rates from rating table dated: Dec. 1, 1934

Date	Time	Time interval	Gage height	Discharge rate: For gage height	Discharge rate: Average for interval		Runoff from area: For interval		Runoff from area: Accumulated			Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13
1936	Hr. min.	Min.	Ft.	C.f.s.	C.f.s.	In./hr.	Cu. ft.	Inches	Cu. ft.	Inches	C.s.m.	
Sept. 28	12:00	720	0.400	0.262	0.262	0.0018	11,318	0.0214	11,318	0.0214		
	2:00p	120	0.390	0.246	0.254	0.0017	1,829	0.0035	13,147	0.0247		
	5:00	180	0.386	0.240	0.243	0.0017	2,624	0.0050	15,771	0.0299		
	9:00	240	0.398	0.259	0.250	0.0017	3,600	0.0068	19,371	0.0367		
	12:00	180	0.400	0.262	0.260	0.0018	2,808	0.0053	22,179	0.0420		
									22,179	0.0420	1.13	Sept. 28 total = 22,179
29	2:00a	120	0.402	0.265	0.264	0.0018	1,901	0.0036	1,901	0.0036		S.R.B. 2:00 a.
	3:00	60	0.438	0.328	0.296	0.0020	1,066	0.0020	1,066	0.0020		
	3:40	40	0.491	0.435	0.382	0.0026	917	0.0017	1,983	0.0038	1.9140	M.P. 3:40 a.
	4:00	20	0.437	0.326	0.380	0.0026	456	0.0009	2,439	0.0046	(0.0030	in./hr.)
	4:30	30	0.455	0.360	0.343	0.0023	617	0.0012	3,056	0.0058		
	6:00	90	0.413	0.284	0.322	0.0022	1,739	0.0033	4,795	0.0091		
	6:20	20	0.428	0.310	0.297	0.0020	356	0.0007	5,151	0.0098		
	6:40	20	0.408	0.275	0.292	0.0020	350	0.0007	5,501	0.0104		
	7:30	50	0.406	0.272	0.274	0.0019	822	0.0016	6,323	0.0120	1.4051	S.R.E. 7:30 a. Total stormflow 6,323
	9:00	90	0.383	0.236	0.254	0.0017	1,372	0.0026	1,372	0.0026		
	12:00	180	0.370	0.216	0.226	0.0015	2,441	0.0046	3,813	0.0072		
	2:00p	120	0.368	0.213	0.214	0.0015	1,541	0.0029	5,354	0.0101		
	5:30	210	0.370	0.216	0.214	0.0015	2,696	0.0051	8,050	0.0152		I S.R.B. 5:30 p.
	5:40p	10	0.400	0.262	0.239	0.0016	143	0.0003	143	0.0002		
	6:00	20	0.450	0.351	0.306	0.0021	367	0.0007	510	0.0010		
	6:20	20	0.477	0.405	0.378	0.0026	454	0.0009	964	0.0018		
	6:40	20	0.500	0.455	0.430	0.0029	516	0.0010	1,480	0.0028		
	7:00	20	0.480	0.411	0.433	0.0030	520	0.0010	2,000	0.0038		
	7:30	30	0.470	0.390	0.400	0.0027	720	0.0014	2,720	0.0052		
	8:00	30	0.488	0.428	0.409	0.0028	736	0.0014	3,456	0.0065		
	8:30	30	0.530	0.525	0.476	0.0032	857	0.0016	4,313	0.0082		
	8:45	15	0.536	0.540	0.532	0.0036	479	0.0009	4,792	0.0091		
	9:00	15	0.600	0.714	0.627	0.0043	564	0.0011	5,356	0.0101		
	9:10	10	0.780	1.364	1.039	0.0071	623	0.0012	5,979	0.0113		
	9:20	10	0.852	1.697	1.530	0.0104	918	0.0017	6,897	0.0131		

Tabulated by H.K.S. Date May 1938 Checked by K.A.M. Date May 1938
Computed by I.W. Date May 1939 Checked by A.C. Date May 1939
Sheet 1 of 3 sheets

RI-SE
WATER RELATIONS
Streamflow
Water Yield

U. S. Department of Agriculture
Forest Service

RECORD OF RUNOFF

Form 6
File No. 3.2211

Expt. Area COWEETA
Station designation No. 7
Discharge rates from rating table dated: Dec. 1, 1934

Date	Time	Time interval	Gage height	Discharge rate			Runoff from area					Remarks
				For gage height	Average for interval		For interval		Accumulated			
1	2	3	4	5	6	7	8	9	10	11	12	13
1936	Hr. min.	Min.	Ft.	C.f.s.	C.f.s.	In./hr.	Cu. ft.	Inches	Cu. ft.	Inches	C.s.m.	
Sept. 29	9:40	20	1.000	2.520	2.108	0.0144	2,530	0.0048	9,427	0.0179		
	10:00	20	1.118	3.319	2.920	0.0199	3,504	0.0066	12,931	0.0245		P. 10:00 p.
	10:30	30	1.060	2.910	3.114	0.0212	5,605	0.0106	18,536	0.0351		
	11:00	30	0.948	2.209	2.560	0.0175	4,608	0.0087	23,144	0.0438		T. 11:00 p.
	11:20	20	1.020	2.646	2.428	0.0166	2,914	0.0055	26,058	0.0494		
	11:40	20	1.100	3.189	2.918	0.0199	3,502	0.0066	29,560	0.0560		
	12:00	20	1.343	5.221	4.205	0.0287	5,046	0.0096	34,606	0.0655		
									50,880	0.0964	2.59	Total Sept. 29 = 50,880
30	12:10a	10	1.534	7.251	6.236	0.0425	3,742	0.0071	38,348	0.0726	31.9044	M.P. 12:10 a.
	12:30	20	1.401	5.796	6.524	0.0445	7,829	0.0148	46,177	0.0875	(0.0495	in./hr.)
	1:00a	30	1.200	3.953	4.874	0.0332	8,773	0.0166	54,950	0.1041		
	2:00	60	0.980	2.397	3.175	0.0217	11,430	0.0216	66,380	0.1257		
	2:20	20	0.970	2.337	2.367	0.0161	2,840	0.0054	69,220	0.1311		T. 2:20 a.
	3:00	40	1.100	3.189	2.763	0.0188	6,631	0.0126	75,851	0.1437		
	3:10	10	1.108	3.247	3.218	0.0219	1,931	0.0037	77,782	0.1473		
	3:30	20	1.090	3.118	3.182	0.0217	3,818	0.0072	81,600	0.1546		
	3:50	20	1.172	3.730	3.424	0.0234	4,109	0.0078	85,709	0.1623		P. 3:50 a.
	4:10	20	1.140	3.483	3.606	0.0246	4,327	0.0082	90,036	0.1705		
	4:30	20	1.168	3.698	3.590	0.0245	4,308	0.0082	94,344	0.1787		
	5:00	30	1.120	3.334	3.516	0.0240	6,329	0.0120	100,673	0.1907		
	6:00	60	1.021	2.653	2.994	0.0204	10,778	0.0204	111,451	0.2111		
	7:00	60	0.925	2.079	2.366	0.0161	8,518	0.0161	119,969	0.2272		
	8:00	60	0.860	1.736	1.908	0.0130	6,869	0.0130	126,838	0.2402		
	9:00	60	0.807	1.484	1.610	0.0110	5,796	0.0110	132,634	0.2512		
	10:00	60	0.764	1.296	1.390	0.0095	5,004	0.0095	137,638	0.2607		
	12:00	120	0.710	1.081	1.188	0.0081	8,554	0.0162	146,192	0.2769		
	2:00p	120	0.668	0.930	1.006	0.0069	7,243	0.0137	153,435	0.2906		
	5:00	180	0.612	0.749	0.840	0.0057	9,072	0.0172	162,507	0.3078		
	8:00	180	0.576	0.645	0.697	0.0048	7,528	0.0143	170,035	0.3220		
	12:00	240	0.548	0.570	0.608	0.0041	8,755	0.0166	178,790	0.3386		
									144,184	0.2731	7.34	Total Sept. 30 = 144,184

~~Tabulated by~~ H.K.S. Date May 1938 Checked by K.A.M. Date May 1938
Computed by I.W. Date May 1939 Checked by A.C. Date May 1939
Sheet 2 of 3 sheets

RI-SE
WATER RELATIONS
Streamflow
Water Yield

U. S. Department of Agriculture
Forest Service

RECORD OF RUNOFF'

Form 6
File No. 3.2211

Expt. Area COWEETA
Station designation No. 7

Discharge rates from rating table dated: Dec. 1, 1934

Date	Time	Time interval	Gage height	Discharge rate: For gage height	Discharge rate: Average for interval		Runoff from area: For interval		Runoff from area: Accumulated			Remarks
1	2	3	4	5	6	7	8	9	10	11		
1936	Hr. min.	Min.	Ft.	C.f.s.	C.f.s.	In./hr.	Cu. ft.	Inches	Cu. ft.	Inches	C.s.m.	
Oct.1	6:00a	360	0.516	0.492	0.531	0.0036	11,470	0.0217	190,260	0.3604		
	12:00	360	0.493	0.439	0.466	0.0032	10,066	0.0191	200,326	0.3794		
	12:00	720	0.465	0.380	0.410	0.0028	17,712	0.0335	218,038	0.4130		S.R.E. 1200 mdt.
									218,038	0.4130	5.5394	Stormflow = 218,038
									39,248	0.0743	2.00	Total Oct. 1 = 39,248
2	11:00a	660	0.450	0.351	0.366	0.0025	14,494	0.0275	14,494	0.0274		
	3:00p	240	0.439	0.330	0.340	0.0023	4,896	0.0093	19,390	0.0367		
	12:00	540	0.438	0.328	0.329	0.0022	10,660	0.0202	30,050	0.0569		
									30,050	0.0569	1.53	Total Oct. 2 = 30,050
3	10:00a	600	0.431	0.315	0.322	0.0022	11,592	0.0220	11,592	0.0220		
	3:00p	300	0.420	0.296	0.306	0.0021	5,508	0.0104	17,100	0.0324		
	12:00	540	0.422	0.299	0.298	0.0020	9,655	0.0183	26,755	0.0507		
									26,755	0.0507	1.36	Total Oct. 3 = 26,755
												Total for 5-day period 313,296

Tabulated by H.K.S. Date May 1938 Checked by K.A.M. Date May 1938
Computed by I.W. Date May 1939 Checked by A.C. Date May 1939
Sheet 3 of 3 sheets

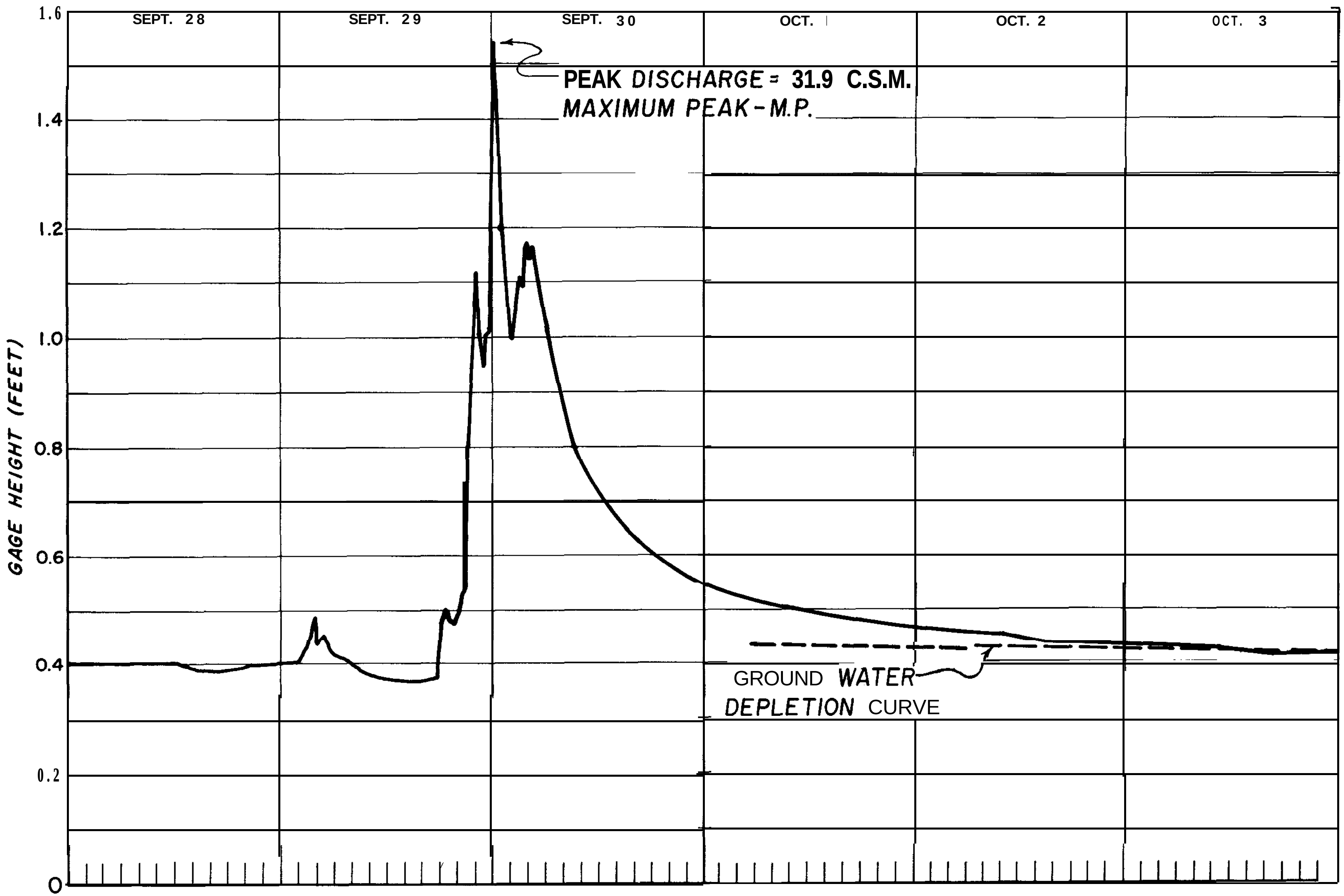

Figure 3. --A stage hydrograph for the period, September 28 to October 3, 1936, irom the I 90° V-notch weir on Watershed 7.

Column 5. Discharge rates in cubic feet per second for the gage heights are obtained from the stage-discharge (rating) table for the measuring device 2/ employed, and are inserted in column 5.

Column 6. In column 6 are recorded the average discharge rates in cubic feet per second for the time intervals of column 3. These values are obtained by averaging the successive discharge rates of column 5.

Column 7. The discharge rates of column 6 are converted into inches per hour and tabulated in column 7. These values are obtained by multiplying each of the column 6 figures by the conversion factor shown in the heading of form 6. The conversion factor equals

$$\frac{3600 \times 12}{43560 \times \text{drainage area in acres}}$$

Column 8. Column 8 is used to record the runoff from the drainage basin in cubic feet for the time intervals of column 3. Column 8 equals column 3 x column 6 x 60 seconds.

Column 9. The runoff from the drainage basin in inches for the time intervals of column 3 are listed in column 9.

$$\text{Column 9} = \text{column 7} \times \frac{\text{column 3}}{60}$$

$$\text{or} \quad \frac{\text{column 8} \times 12}{\text{drainage area in acres} \times 43560}$$

Column 10. Column 10 shows the accumulated runoff from the drainage basin in cubic feet. It is obtained by adding the values in column 8 and recording the sum opposite the last figure added. Thus, any value in column 10 represents the total runoff from the starting point to the time shown in column 2. In order to show total runoff by days, starting points for accumulated runoff are always taken at midnight. For storm studies, starting points are also taken at the beginning of storm runoff and stopped at the end of the stormflow. Accumulated runoff during a storm is carried beyond midnight to the end of storm flow, in which case the daily total runoff is recorded on the blank line which follows each midnight. Total storm runoff is similarly recorded.

Column 11. The values in column 10 are converted into inches and recorded in column 11.

$$\text{Column 11} = \frac{\text{Column 10} \times 12}{\text{drainage area in acres} \times 43560}$$

2/ For the 90-degree V-notch weir used in the following example see H. W. King, Handbook of Hydraulics, table 44, pp. 4-59 to 4-62, 4th Edition, McGraw Hill, New York, 1954.

Column 12. Column 12 is used for showing the mean dail discharge in cubic feet per second per square mile (c. s. m.).[3]

$$\text{Column 12} = \frac{\text{column 10 (daily total) x 640}}{\text{drainage area in acres x 86400}}$$

The maximum peak discharge rate in cubic feet per second is converted to cubic feet per second per square mile and inches per hour and these are also recorded in column 12.

Column 13. The remarks inserted in column 13 must include the following:

Peak (P) noted at each point where the hydrograph changes from a rising to a falling stage.

Maximum Peak (M. P.) the highest peak of the entire storm.

Trough (T) noted at each point where the hydrograph changes from a falling to a rising stage.

For special storm studies, the time storm (or surface) runoff begins (S. R. B.) and the time storm (or surface) runoff ends (S.R.E.) are also noted.

Column 13 is also used for recording any observations, remarks, or notes pertaining to the chart recorded or to any of the computations required in executing the form.

RUNOFF SUMMARIES

Drainage Discharge Data- - Forms 7 and 7a

These forms are used for summarizing the discharge or runoff data from an individual drainage basin. Form 7 is for the growing season, May 1 to October 31, and form 7a is for the dormant season, November 1 to April 30. The mean discharge in c.f. s. per square mile (c. s. m.) is obtained from column 12, form 6, and tabulated for each day. These data are plotted as a continuous streamflow hydrograph (fig. 4) which in turn is used as a guide in estimating missing records and as a basis for streamflow analyses. Note on form 7 the line in column 2, May, from May 13 through May 15 and the accompanying footnote. This indicates that the record for this period has been estimated. If for some reason data are missing or lost, as for instance when the weir is being cleaned or repaired, the record may be estimated from the record of an adjacent watershed.

3/ The heading of this column is left blank so that conversions or data required for special studies may be inserted.

RI-SE
WATER **RELATIONS**
Streamflow
Water Yield

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Form 7
File No. 3.2212

Expt. Area Coweeta WATERSHED DISCHARGE DATA

Mean Discharge in C.s.m. by Days, Months, and Season

Computed by H.K.S.
Checked by K.A.M.

Watershed 7 Area 145.5 A.

Date	Discharge by Months for Growing Season 1936								
	May	June	July	Aug.	Sept.	Oct.			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	5.29	2.61	1.76	1.87	1.06	2.03			
2	5.14	2.56	3.04	1.65	1.06	1.53			
3	5.28	2.51	1.97	1.50	1.56	1.36			
4	4.88	2.85	2.20	1.40	1.17	1.27			
5	4.68	2.54	1.76	1.36	1.08	1.23			
6	4.73	2.49	1.73	1.31	1.06	1.26			
7	4.48	2.44	1.67	1.35	1.04	1.34			
6	I h.33	2.48	1.63	1.30	1.02	1.57			
9	4.22	2.43	1.67	1.27	1.05	1.70			
10	4.13	2.70	1.64	1.30	1.05	1.83			
11	4.81	2.48	1.68	1.23	1.01	1.49			
12	4.87	2.84	2.56	1.19	1.02	1.38			
13	1/4.24	2.47	2.03	1.18	0.98	1.34			
14	1/4.07	2.29	1.78	1.17	0.96	1.28			
15	1/3.94	2.23	1.68	1.16	0.99	1.26			
16	3.83	2.13	1.64	1.14	0.95	1.63			
17	3.72	2.06	1.94	1.17	0.95	1.35			
18	3.54	2.10	1.67	1.09	0.92	1.28			
19	3.59	2.07	1.58	1.35	1.03	1.24			
20	3.45	2.06	1.56	1.14	1.70	1.22			
21	3.45	2.01	1.65	1.10	1.08	1.20			
22	3.25	1.99	1.51	1.07	0.98	1.21			
23	3.14	2.00	1.49	1.12	0.95	1.64			
24	3.11	1.96	1.50	1.45	1.12	1.30			
25	3.03	1.87	1.47	1.23	1.00	1.26			
26	2.96	1.84	1.42	1.15	1.00	1.34			
27	3.06	1.76	1.38	1.11	1.04	1.25			
28	2.89	1.73	1.36	1.27	1.13	1.22			
29	2.80	1.69	1.37	1.34	2.59	1.20			
30	2.75	1.65	1.82	1.15	7.44	1.17			
31	2.67		1.81	1.09		1.15			
Total	120.33	66.84	53.97	39.21	39.99	42.48			
Mean	3.88	2.23	1.74	1.26	1.33	1.37			
Area Inches	4.48	2.49	2.01	1.46	1.49	1.58			
Precip. Inches	2.62	4.02	7.87	4.30	10.14	4.67			
Runoff % Precip.	171.0	61.9	25.5	34.0	14.7	33.8			

	For 6 Months Ending Oct.31	For 12 Months Ending Oct. 31
Total	[illegible]	[illegible]
Mean	1 .97	3.14
Area Inches	13.49	42.78
Precip. in Inches	33.62	83.03
Runoff as % of Precip	40.1	51.5

Period May 1, 1936 to October 31, 1936

Sheet 1 of 2 sheets

1/ **Weir** being repaired--flow **estimated** from **an** adjacent watershed.

RI-SE
WATER RELATIONS
Streamflow
Water Yield

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Form 7a
File No. 3.2212

Expt. Area Coweeta **WATERSHED DISCHARGE DATA**

Mean Discharge in C.s.m. by Days, Months, and Season

Computed by H.K.S.
Checked by K.A.M.

Watershed 7 Area 145.5 A.

Date	Discharge by Months for Dormant								Season 1936-1937
	Nov.	Dec.	Jan.	Feb.	March	April			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	1.15	1.11	5.69	5.44	4.53	3.23			
2	1.14	1.19	9.47	5.20	4.42	3.20			
3	1.15	1.48	11.75	5.05	4.40	3.19			
4	1.41	1.18	7.55	4.92	4.40	3.56			
5	1.23	1.14	6.62	4.80	4.28	4.68			
6	1.26	1.84	6.08	4.62	4.16	4.43			
7	1.22	3.19	5.53	4.93	4.16	3.97			
8	1.22	1.88	5.11	4.93	4.32	4.67			
9	1.16	1.58	4.74	7.19	4.07	4.45			
10	1.14	1.48	4.45	6.41	4.00	4.10			
11	1.14	1.58	4.40	5.56	3.93	3.91			
12	1.40	1.44	4.35	5.20	3.82	3.72			
13	1.15	1.38	4.24	5.14	3.80	3.62			
14	1.12	1.38	4.09	5.08	3.88	3.60			
15	1.12	1.39	5.02	4.90	4.10	3.58			
16	1.10	1.41	4.52	4.85	3.94	3.35			
17	1.12	1.35	4.71	4.59	3.85	3.22			
18	1.12	1.55	6.07	4.59	3.83	3.15			
19	1.10	5.03	7.53	4.43	3.69	3.14			
20	1.07	3.58	6.91	5.69	3.66	3.11			
21	1.05	2.62	6.23	6.03	3.58	3.30			
22	1.06	2.25	5.74	5.60	3.47	3.29			
23	1.06	2.03	5.45	5.26	3.43	3.23			
24	1.07	1.92	5.40	5.11	3.77	3.69			
25	1.06	1.83	6.34	4.90	3.82	5.89			
26	1.05	1.76	5.78	4.74	3.61	4.42			
27	1.02	1.75	5.44	4.66	3.53	3.97			
28	1.03	1.92	5.61	4.64	3.39	3.89			
29	1.03	2.69	5.27		3.32	4.74			
30	1.02	2.83	5.08		3.27	4.34			
31		8.59	5.64		3.23				
Total	33.97	66.35	180.81	144.46	119.66	114.64			
Mean	1.13	2.14	5.83	5.16	3.86	3.82			
Area Inches	1.26	2.47	6.72	5.37	4.45	4.26			
Precip. Inches	1.60	10.62	12.27	5.63	2.81	7.33			
Runoff % Precip.	78.8	23.3	54.8	95.4	158.4	58.1			

	For 6 Months Ending April 30	For 12 Months Ending April 30
Total	659.89	1022.71
Mean	3.65	2.80
Area Inches	24.54	28.03
Precip. in Inches	40.26	73.88
Runoff as % of Precip.	61.0	51.5

Period November 1, 1936 to April 30, 1937

Sheet 2 of 2 Sheets

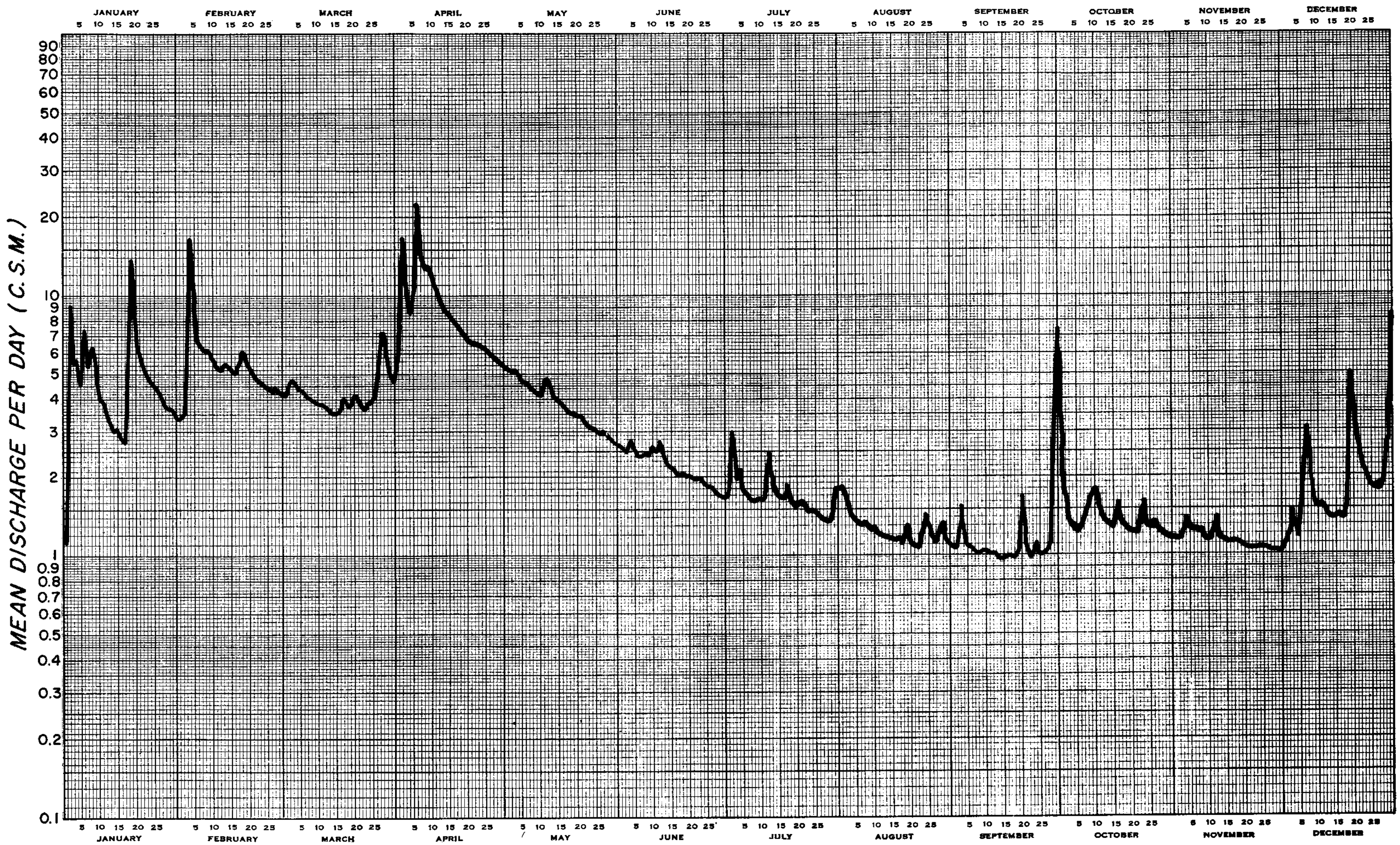

Figure 4.--Stream hydrograph of mean daily discharge, Watershed 7, for 1936.

At the bottom of the page the data are summarized by months, seasons, and years as follows:

Total: The summation of the daily discharges for the month, season and year. This number has no significance but is used in the computations which follow.

Mean: Mean daily c. s. m. for the period =

$$\frac{\text{total of mean daily discharge}}{\text{number of days}}$$

Area inches: The volume of runoff expressed as inches depth on the drainage area.

$$\frac{\text{(Total of mean daily discharge) x 86,400 sec.}}{2,323,200}$$

2, 323,200 cubic feet = l-inch depth on 1 square mile.

Inches precipitation: The weighted mean precipitation on the drainage basin taken from form 2.

Runoff as a percent of the precipitation = $\frac{\text{area inches runoff}}{\text{inches precipitation}}$

Stream Hydrograph and Summary by Hydrologic Years

In compiling runoff data, two other runoff summaries are ordinarily made in addition to the drainage discharge data. The first of these is the actual stream hydrograph for a calendar year (fig. 4), in which the mean daily discharge in c. s. m. is shown graphically by days and months. Periods of high and low flows as well as the hydrologic seasons show up on the stream hydrograph.

The second summary consists of a tabulation of total discharge from a given drainage area by months and years on the basis of hydrologic years, i.e., from November through the following October. An example of this summary is given on the following page,

Maximum and Minimum Flow Tabulations

For various flood control and water yield studies, it is frequently desirable to have a compilation of maximum and/or minimum flows. For other special studies, compilations of all stream rises or all stream flows over a given base may be made. On such compilations, the purpose, date, time of peak, head, flow in c. f. s., c. s .m., and inches per hour and pertinent remarks such as type of storm should be indicated. A tabulation of the annual instantaneous maximum flood peak discharges for Coweeta Watershed No. 18 is shown on page 27.

RI-SE
WATER RELATIONS
Streamflou
Water Yield
Expt. Area Coweeta

File No. j.22131

U. S. Department of Agriculture
Forest Service
ANNUAL RECORD BY MONTHS OF
RUNOFF DATA
FOR AN INDIVIDUAL DRAINAGE AREA
(Area inches)

Watershed No. 18 Area 30.84 acres

Computed by W.C.
Checked by E.A.J.

Water year	Total	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.
1935													
1936										1.27	0.94	1.05	1.49
1937	39.07	1.16	3.07	10.03	6.63	4.32	4.14	3.47	2.00	1.26	1.00	.75	1.24
1938	31.23	.91	1.65	2.22	1.96	4.11	5.19	3.12	2.58	3.22	3.31	1.80	1.16
1939	45.09	2.38	1.88	3.12	12.75	9.91	5.37	3.57	2.05	1.53	1.29	.69	.55
1940	21.12	.42	.53	.70	1.72	1.97	3.90	2.95	2.18	1.45	2.24	1.83	1.23
1941	17.84	1.36	1.47	2.09	1.67	2.29	2.67	1.74	1.08	1.65	.83	.54	.45
1942	31.70	.59	1.58	2.06	4.29	6.73	3.89	4.10	2.44	2.09	1.48	1.31	1.14
1943	44.66	1.10	4.73	5.79	6.30	6.09	5.10	3.76	2.35	3.61	2.78	1.78	1.27
1944	37.13	1.14	1.14	2.17	4.87	9.17	7.92	4.47	2.16	1.34	1.08	.98	.69
1945	26.26	.85	1.30	2.28	3.28	4.06	4.64	4.04	1.97	1.23	.93	.99	.69
1946	44.43	.83	2.05	7.67	7.28	7.65	5.12	5.62	3.01	2.09	1.20	.99	.92
1947	30.68	.96	1.21	5.86	3.59	4.07	4.94	3.50	2.17	1.41	1.14	.79	1.04
1948	40.97	1.80	2.14	2.66	6.91	7.86	6.73	3.36	1.71	2.20	3.02	1.52	1.06
1949	65.38	5.49	6.37	8.64	6.99	5.30	5.88	5.89	5.48	4.69	3.55	3.79	3.31
1950	46.42	4.08	4.36	5.23	5.56	7.65	4.46	2.98	2.24	1.69	1.68	4.05	2.44
1951	32.47	1.85	3.24	2.69	3.18	4.54	5.17	3.26	2.85	2.25	1.31	1.15	.98
1952	46.28	1.52	5.97	5.27	5.59	13.15	6.28	3.38	2.08	.91	.91	.69	.53
1953	29.38	.72	1.23	3.27	6.18	5.61	3.74	3.26	1.98	1.39	.86	.65	.49
1954	35.90	.62	2.12	6.37	4.26	6.26	5.88	4.00	2.57	1.81	1.07	.54	.40

Watershed data :
Max. elevation 3258 ft.
Min. elevation 2382 ft.
Mid. elevation 2703 ft.

Control:
120° V-notdh blade

RI-SE
WATER RELATIONS
Streamflow
Expt. Area Coweeta

U. S. Department of Agriculture
Forest Service
ANNUAL INSTANTANEOUS MAXIMUM FLOW
DISCHARGE FOR AN INDIVIDUAL DRAINAGE AREA

File No. 3.2102

Watershed No. 18

Area 30.84 acres

Computed by E.A.J.
Checked by J.L.K.

Calendar year	Date		Head	Discharge		Remarks
			Feet	C.f.s.	C.s.m.	
1936	9-30	0020	0.802	2.565	53.22	Records begin June 3, 1936
	4-25	0030	.584	1.187	24.63	
1938	11-5	0250	1.130	5.976	124.00	
1939	2-3	1230	1.035	4.819	99.99	
1940	8-29	2220	.795	2.526	52.41	
	7-5	1045	.484	.749	15.55	
1942	5-20	1010	.744	2.154	44.70	
1943	7-5	1840	.616	1.352	28.05	
1944	3-27	0150	.573	1.132	23.49	
1945	3-18	1800	.464	.676	14.02	
1946	2-10	1115	.630	1.429	27.65	
1947	8-25	1320	.935	3.758	77.98	
	8-2	0615	.800	2.565	53.22	
1949	6-16	0720	.774	2.373	49.24	
1950	8-30	1600	.621	1.374	28.51	
1951	7-15	1250	.642	1.485	30.81	
1952	3-10	2300	.827	2.766	57.39	
1953	6-13	1900	.617	1.347	27.95	
1954	6-16	1120	.680	1.723	35.75	
1955						
1956						
1957						
1958						
1959						
1960						

SPECIAL WATER-YIELD COMPUTATIONS

Within the past few years two other methods of computing water yield have been tested and used to a limited extent at the Coweeta Hydrologic Laboratory. The first of these two methods was devised by the Mountain State Research Center, Northeastern Forest Experiment Station, and effects a considerable saving in computing time by reducing the number of points on the hydrograph used in the calculations. The second method is the application of the U. S. Geological Survey Discharge Integrator.

Northeastern Station Method

This method was adapted from U. S. Geological Survey techniques. Through a change in the conventional method of marking the charts, the office work involved in computing and tabulating water yield may be reduced by effecting a reduction in the number of points or "breaks" in the hydrograph used in the calculations. In the "Form 6 Method" described previously, calculation points were marked on the hydrograph at all breaks in the curve of the hydrograph and at all peaks and troughs as well as at midnight, storm beginning, and storm ending. In this method the breaks at storm beginning, maximum peak, and midnight are still utilized, but all other calculation points are made only where there is an appreciable rise or fall in discharge.

The allowable rise or fall before a calculation point is made depends upon a head-discharge relation that has been worked out and tabulated in a range table (table of permissible rise or fall in head for a given head range value). The permissible rise or fall is determined by the following rule: "Points on the hydrograph are made when the difference in discharge between consecutive heads exceeds one and one-half times the difference in discharge between heads where the previous break was made."

Using a 90° V-notch rating table, the range table may be derived by using the following procedure. Assume a head reading of 0.300 foot as a starting point. For the next reading use 0.310 foot. Referring to the rating table, the difference in discharge between the two head readings is 0.0109 c.f.s. One and one-half times this value is 0.0153 c.f.s. Refer again to the rating table and by inspection find the next highest paired values of head readings where the difference in discharge just exceeds 0.0153 c.f.s., i.e., 0.0154 c.f.s. In this case the paired head values are 0.369 and 0.379 foot. The difference between the head readings (0.369 - 0.300 or 0.069 foot) then is the permissible rise or fall in head for a head reading of 0.300 foot. This process may be repeated for each tenth of a foot change in head or at least often enough to define a curve of permissible rise in head over head for the range of values you expect to find on the hydrograph. The values for permissible rise in head are plotted against corresponding heads and a smooth curve is fitted to these data. From these curved values the final range table is made. The actual range of head values is arbitrary, i.e., 0.301 - .325, 0.326 - .350, etc. ,or 0.301 - .350, 0.351 - .400, etc. A range table constructed for the 90° and the 120° V notch weirs is given on the following page.

RI-SE
WATER RELATIONS
Streamflow
Computations
Area Coweeta

File No. 3.2231

U. S. Department of Agriculture
Forest Service
RANGE TABLE FOR COMPUTING WATER YIELD
BY NORTHEASTERN STATION METHOD

Head range (Feet)	Permissible rise or fall in head: 90° V-Notch	Permissible rise or fall in head: 120° V-Notch
	Feet	Feet
0.301- .350	0.092	0.080
.351- .400	.110	.100
.401- .450	.127	.110
.451- .500	.144	.120
.501- .550	.161	.140
.551- .600	.178	.150
.601- .650	.195	.170
.651- .700	.212	.180
.701- .750	.229	.200
.751- .800	.245	.210
.801- .850	.262	.230
.851- .900	.280	.240
.901- .950	.297	.250
.951-1.000	.315	.270
1.001-1.050	.331	.280
1.051-1.100	.350	.290
1.101-1.150	.365	.310
1.151-1.200	.382	.320
1.201-1.250	.400	.340
1.251-1.300	.416	.360
1.301-1.350	.434	.370
1.351-1.400	.450	.380
1.401-1.450	.468	.400
1.451-1.500	.485	.420
1.501-1.550	.501	.430
1.551-1.600	[illegible]	.450
1.601-1.650	.537	.460
1.651-1.700	.555	.470

To illustrate the application of the table, assume that storm flow starts at a head reading of 0.831 foot. Referring to the range table, a permissible rise of 0.262 foot is indicated. The next computing point on the hydrograph would then be made where the head reading was 1.093 feet (0.831 plus 0.2621, assuming that the maximum peak of midnight does not intervene.

The second step in the method is in the computing. Once the calculation points have been established, the exact head for the time interval between two consecutive points is determined by placing a plastic straightedge or template horizontally on that portion of the hydrograph in question and then balancing by inspection the areas above and below the edge or line and the curve (the areas bounded by the hydrograph curve, the horizontal line and the time ordinates of the two points--areas A and B in figure 5). Discharge is recorded only for the head reading at the intersection of the horizontal line and the hydrograph. This head value is multiplied by the time interval in seconds to obtain the interval discharge in cubic feet.

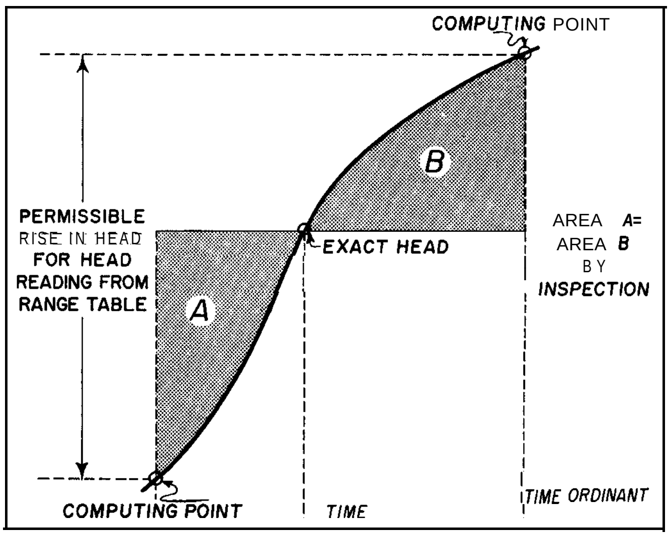

Figure 5. --Schematic representation of Northeastern method for weighting areas in determining an average head and estimating time interval for computing water yield.

Step one in this method results in a saving in computing'time, since less than half as many points are marked on the hydrograph. The second step effects a reduction in office work, since only one entry for discharge is now necessary. Under the "Form 6" method it was necessary to enter discharge for each break and then average the values for the interval discharge.

The regular Form 6, Record of Runoff, may be adapted for use with this method . For comparison, runoff for the same storm period as used in illustrating the conventional method of computing water yield has been calculated and tabulated utilizing this method, and is given in the Record of Runoff on the following page. Note the difference between the two methods in number of entries and in water yield values. For the 6-day period the difference in water yields amounts to only 0.063 percent and the largest daily difference was 0.17 percent (for September 30) when compared with results obtained when the conventional method was used.

RI-SE
WATER RELATIONS
Streamflow
Water Yield

U. S. Department of Agriculture
Forest Service

RECORD OF RUNOFF BY NORTHEASTERN STATION METHOD

Form 6
File No. 3.2211

Expt. Area Coweeta
Station designation No. 7

Discharge rates from rating table dated: Dec. 1, 1934

Date 1936	Time	Time interval	Gage height	Discharge rate: For gage height	Discharge rate: Average for interval		Runoff from area: For interval		Runoff from area: Accumulated			Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13
Sept.	Hr. min.	Min.	Ft.	C.f.s.	C.f.s.	In./hr.	Cu. ft.	Inches	Cu. ft.	Inches	C.s.m.	
28	0000	-										
	2400	1440	0.398	0.259			22,378		22,378			Sept. 28 total 22,378 c.f.
29	0200	120	0.401	0.264			1,901		1,901			SRB
	0345	105	0.420	0.296			1,865		3,766			P
	1735	830	0.394	0.252			12,550		16,316			SRB
	1830	55	0.425	0.305			1,007		17,323			P
	2100	150	0.510	0.478			4,302		21,625			
	2120	20	0.780	1.364			1,637		23,262			
	2200	40	0.992	2.470			5,928		29,190			P
	2300	60	1.040	2.776			9,994		39,184			T
	2355	55	1.047	2.823			9,316		48,500			
	2400	5	1.350	5.288			1,586		50,086			Sept. 29 Total 50,086 c.f.
30	0010	10	1.460	6.417			3,850		3,850			MP
	0220	130	1.192	3.889			30,334		34,184			T
	0350	90	1.086	3.090			16,686		50,870			P
	0930	340	0.986	2.434			49,654		100,524			
	2400	870	0.642	0.843			44,005		144,529			Sept. 30 Total 144,529 c.f.
Oct.												
1	2400	1440	0.500	0.455			39,312		39,312			Oct. 1 Total 39,312 c.f.
2	2400	1440	0.447	0.345			29,808		29,808			Oct. 2 Total 29,808 c.f.
3	2400	1440	0.427	0.308			26,611		26,611			Oct. 3 Total 26,611 c.f.
												Sept. 28 to Oct. 3 Total for period 312,724 c.f.

Tabulated by RD Date 3/55 Checked by JLK Date 3/55
Computed by CS Date 3/55 Checked by EAJ Date 3/55
Sheet 1 of 1 sheets

Tests on this method indicate that results obtained are within an error of plus or minus 2 percent for daily, weekly, or monthly discharges when compared to discharge values determined by both the Form 6 method and by using the U.S.G.S. Discharge Integrator.

It should be noted that this method cannot be used for storm studies without alteration and that additional experience is ordinarily required in properly selecting the exact head used in the computing.

Discharge Integrator

A discharge integrator has been developed by the U. S. Geological Survey for use in streamflow calculations. The integrator is shown in figure 6. It is designed to give discharge values directly in cubic feet per second. The basic principle of the integrator might be considered as a compensating planimeter. A different setting is required for each weir rating and type of chart. Once the proper adjustments have been made for these settings on the instrument, the integration or compilation of streamflow is very simple, accurate and rapid.

Detailed instructions and procedure for the operation of the discharge integrator have been outlined in U. S. Geological Survey publications.

When compiling streamflow data by means of the integrator at the Coweeta Hydrologic Laboratory, we use Form 8, shown on the following page. Discharge in mean daily c .f. s. is read directly from the instrument and by the application of appropriate conversion factors daily values may also be given in c.s.m., cubic feet, or area inches.

The discharge integrator effects a tremendous saving in time required for compiling water-yield data. After the instrument is properly set, approximately 1 year of stream discharge record may be computed in an 8-hour day.

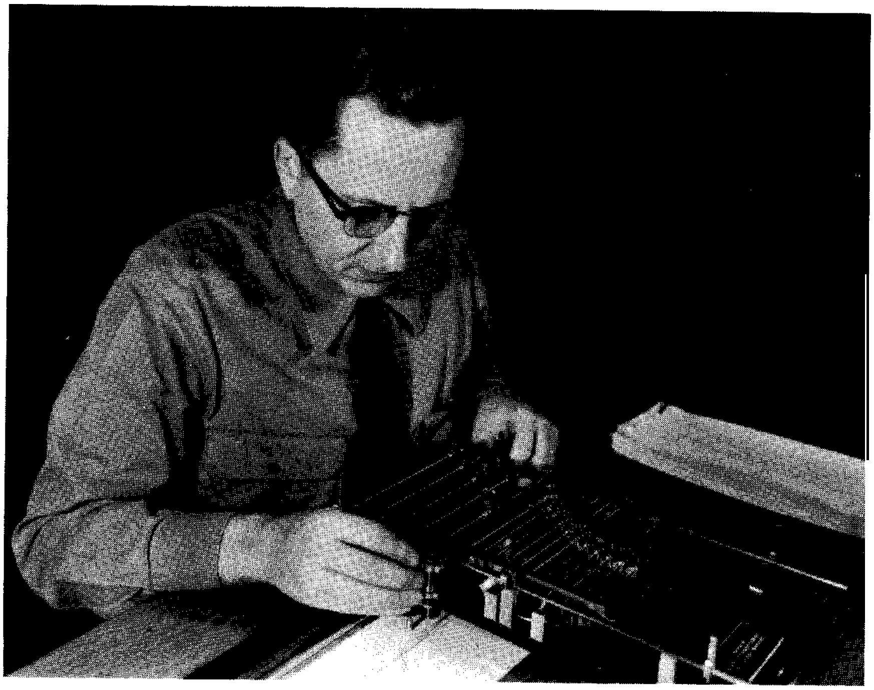

Figure 6.- Discharge integrator.

RI-SE
WATER RELATIONS
Streamflow
Water Yield
Expt. Area Coweeta

U. S. Department of Agriculture
Forest Service
RECORD OF RUNOFF
BY DAYS FOR AN INDIVIDUAL DRAINAGE AREA

Form 8
File 3.2212

Watershed No. 7
Control 90° V-notch

Area 145.5 Acres
Conversion factor
c.f.s. to c.s.m.
4.400

Integrator setting Oct. 1954
Integrator operator W. Curtis
Compilation by B. Cunningham
Computed by C. Swafford, 3/55

Date	Mean daily c.f.s.	C.s.m.	Cubic feet	Area inches	Remarks
July 1936 (1)	(2)	(3)	(4)	(5)	(6)
1	0.400	1.76	34,560	0.065	
2	.686	3.04	59,270	.113	
3	.448	1.97	38,710	.073	
4	.500	2.20	43,200	.082	
5	.400	1.76	34,560	.065	
6	.393	1.73	33,955	.064	
7	.380	1.67	32,830	.062	
8	.371	1.63	32,054	.061	
9	.380	1.67	32,830	.062	
10	.373	1.64	32,230	.061	
11	.382	1.68	33,005	.063	
12	.582	2.56	50,285	.095	
13	.458	2.03	39,570	.075	
14	.405	1.78	34,990	.066	
15	.382	1.68	33,005	.063	
16	.373	1.64	32,230	.061	
17	.441	1.94	38,100	.072	
18	.380	1.67	32,830	.062	
19	.359	1.58	31,020	.059	
20	.355	1.56	30,670	.058	
21	.375	1.65	32,400	.061	
22	.343	1.51	29,635	.056	
23	.339	1.49	29,290	.055	
24	.341	1.50	29,460	.056	
25	.334	1.47	28,860	.055	
26	.324	1.42	27,994	.053	
27	.314	1.38	27,130	.051	
28	.309	1.36	26,700	.051	
29	.312	1.37	26,960	.051	
30	.414	1.82	35,769	.068	
31	.413	1.81	35,680	.068	
Totals	12.266	53.97	1,059,782	2.007	

Ground Water Depletion Curves

The ground water depletion curve or the master recession curve is a useful hydrologic tool in various special studies. It is particularly applicable in the separation of base flow in storm hydrograph studies. Depletion curves may be constructed graphically by systematically matching arcs from a basin hydrograph or by arithmetic means. Only hydrographs for nonstorm periods are used for this purpose. A procedure used at the Coweeta Hydrologic Laboratory to calculate a depletion curve for a given drainage basin is described below.

The rate at which the ground water flow gradually decreases follows a die -away type exponential curve. For the time interval from maximum to lowest rates of ground water flow a depletion curve has been obtained by using the formula:

$$Q = Q_0 e^{-kt} \qquad (1)$$

where

Q = rate of discharge in c. s. m. at time t

Q_o = initial rate of discharge in c. s. m. at time $t = o$

e = base of natural logarithms

t = time in days

k = a watershed constant

A better fit of this decreasing ground water flow into a depletion curve has been obtained by using the formula:

$$Q = Q_0 e^{-kt^n} \qquad (2)$$

In this equation n is another watershed constant. Equations (1) and (2) can be reduced to a linear form by taking common logarithms of both sides. For example, equation (2) in double logarithm form becomes:

$$\log (\log Q_o - \log Q) = n \log t + \log k - 0.362216$$

where corresponding to the familiar

$Y = ax + b$

$Y = \log (\log Q_o - \log Q)$

$x = \log t$

$a = \log k - 0.362216$

$b = n$

Once values of t and Q have been determined, equations (1) and (2) can be solved for the constants using the method of least squares.

During the period while ground water is diminishing, rains occur that produce storm flow which distorts the true time scale and does not permit the continuous development of a complete depletion curve. To overcome this, it is necessary to employ segments of the hydrograph that represent rainless periods. The mean daily discharges during the depletion season for all years on record are examined and tabulated for periods consisting of 6 or more successive days with ground water flow. Several methods may be used in this selection. For example, all nonstorm periods over 10 days are noted, and 4 days after the end of precipitation are allowed for removing any influence of subsurface flow. This results in a minimum series of at least 6 days of ground water depletion.

Another procedure has been to work directly with the stream hydrograph of mean daily discharge (fig. 4) and select the periods with distinct ground water flow. The individual periods are then arranged in order of decreasing magnitude, with the maximum discharge at the top. Table 1 shows how this arrangement of synchronizing the individual depletion periods is carried out.

Fitting the individual series from the various periods together for an average discharge requires some judgement. However, computers with varying degrees of experience have turned out essentially the same average series for plotting on logarithmic paper with no significant differences to the constants in equations (1) and (2). The method of least squares is used to fit the values of t and Q for computing the curve and formula. Figure 7 shows the derived curve for Coweeta Watershed No. 18.

For routine use, it is most convenient to convert the curve from figure 7 to read directly in gage height over the weir and adjust to the time scale of the original field chart. This adjusted curve is then transferred to transparent cloth or clear plastic and used as an overlay on the original record for separating base flow from storm hydrographs.

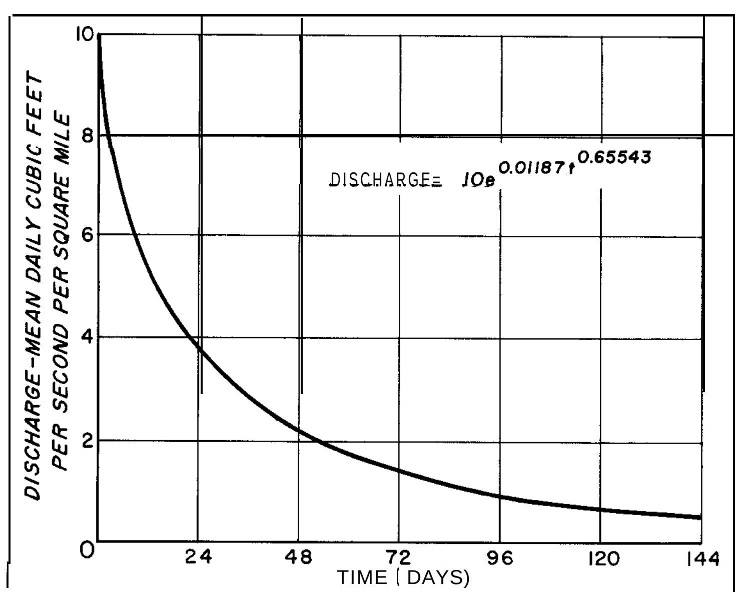

Figure 7. --Normal ground-water depletion curve, Watershed 18.

Table 1.--Procedure for synchronizing periods of base flow to derive normal. curve of ground water depletion

t (Days)	Beginning date of periods					Average depletion Q
	4/2/44	4/11/49	3/12/39	4/4/39	4/13/48	
	C.s.m.	C.s.m.	C.s.m.	C.s.m.	C.s.m.	C.s.m.
0	9.87	--	9.82	--		9.85
1	8.99	--	8.82	--	--	8.90
2	8.3%	--	8.21	--	--	8.27
3	7.79	7.91	8.01	--	--	7.90
4	7.30	7.57	7.93	--	--	7.48
5	6.95	7.10	7.08	--	--	7.04
6	6.69	6.71	6.74	--	--	6.71
7	6.44	6.36	6.41	--	--	6.40
8	--	6.15	6.18	--	--	4.16
9	--	--	5.95	--	--	5.95
10	--	--	4.75	--		5.75
11	--		5.64	5.62	--	5.63
12		--	5.53	5.45	--	5.49
13	--	--	5.39	5.30	--	5.34
14	--	--	--	5.02	--	5.02
15	--	--		4.86	4.92	4.89
16	--	--	--	4.72	4.74	4.73
17	--	--	--	4.66	4.61	4.63
18		--	--	4.40	4.54	4.47
19		--		4.32	4.37	4.34
20	--	--		4.26	4.25	4.26

GROUND WATER

The third phase of basic water-resource accounting consists of recording and tabulating ground water data. Ground water levels or water table elevations from shallow wells can be measured and recorded by use of a water level recorder. Form 100, Record of Water Table Elevations, is used in compiling ground water data.

Record of Water Table Elevations--Form 100

Actual water table elevations may be read from the recorder chart for any desired time. Form 100 uses the hours of 8 a. m. or 5 p. m. or both. The readings are recorded by days and months on the form. Elevation of the water table above mean sea level is recorded unless otherwise specified and noted in the remarks section on the form. One sheet is used for the dormant season, November through April, and one for the growing season, May through October.

At the top of the form, appropriate information should be entered in the proper blanks to describe the well and the location. At the bottom of the form, space is provided for remarks, maximum, minimum, and range of water levels for the period. Forms 100 and 100a are shown on the following pages.

Ground Water Summaries

Ground water data are commonly summarized graphically by plotting daily values for the hydrologic year in the same fashion that stream discharge values are given. Figure 8 gives an example of such a summary.

For special studies such as daily fluctuations in the water table, hourly values may be taken from the recorder chart and either tabulated or shown graphically.

RI-SE
WATER RELATIONS
Ground Water

U. S. Department of Agriculture
Forest Service

Form 100
File No. 3.51

WATER TABLE ELEVATIONS

Experimental Forest Coweeta Well Number 6
Drainage Area 6 Period: November 1, 1947 April 30, 1948
Well Diameter Dug Depth Reference Iron Elevation 2352.45
Recorder 365-A Scale 1:1 Date Installed Sept. 29, 1938

Dormant Season

Date	November 8A	November 5P	December 8A	December 5P	January 8A	January 5P	February 8A	February 5P	March 8A	March 5P	April 8A	April 5P
1	2333.93		.51		35.42		35.22		35.66		36.63	
2	.94		.48		.39		.21		.63		.47	
3	.98		.45		.36		.22		.59		.40	
4	.99		.43		.34		.27		.54		.38	
5	.99		.42		.32		.34		.51		.35	
6	2334.07		.39		.32		.40		.50		.30	
7	.12		.38		.34		.44		.68		.26	
8	.17		.37		.36		.48		36.44		.19	
9	.23		.32		.37		.51		.79		.13	
10	.28		.29		.36		.55		.74		.16	
11	.29		.27		.36		.67		.58		.31	
12	.30		.26		.36		.86		.41		.38	
13	.37		.24		.38		36.73		.28		.31	
14	.48		.22		.36		37.85		.18		.27	
15	.66		.20		.31		38.63		.11		.19	
16	.86		35.18		.30		37.90		.02		.12	
17	2335.11		.23		.31		37.45		35.91		.06	
18	.45		.62		.32		.07		.80		35.97	
19	.72		.62		.32		36.82		.75		.90	
20	.82		.63		.33		.63		.68		.85	
21	.84		.64		.36		.46		.62		.83	
22	.83		.66		.36		.36		.59		.78	
23	.81		.67		.35		.21		.57		.73	
24	.78		.66		.35		.10		.52		.70	
25	.74		.63		.30		.01		.50		.68	
26	.71		.62		.28		35.97		.51		.65	
27	.65		.59		.27		.89		.64		.61	
28	.61		.54		.27		.84		37.35		.59	
29	.57		.50		.25		.73		.28		.57	
30	.55		.47		.24				.00		.55	
31			.43		.23				36.82			

Remarks M.P. 11/21 - 2335.84 M.P. 2/15/48 - 2338.92 M.P. 3/28/48 - 2337.45

Maximum for Period 2338.92 2/15 Minimum for Period 2333.93 11/1 Maximum Range 4.99
Observer: R. S. Pierce Recorder: R. S. Pierce Checked by: E. A. Johnson

Elevation of the water table above mean sea level is recorded unless otherwise shown by remarks. The figures for hundreds of feet are omitted, Example, 2264.12 is recorded as 64.12.

RI-SE
WATER RELATIONS
Ground Water

U. S. Department of Agriculture
Forest Service

Form 100a
File No. 3.51

WATER TABLE ELEVATIONS

Experimental Forest Coweeta Well Number 6
Drainage Area 6 Period: May 1, 1948 - October 31, 1948
Well Diameter ____ Dug Depth ____ Reference Iron Elevation 2352.45
Recorder 365-A Scale 1:1 Date Installed Sept. 29, 1938

Growing Season

Date	May 8A	May 5P	June 8A	June 5P	July 8A	July 5P	August 8A	August 5P	September 8A	September 5P	October 8A	October 5P
1	35.53		35.19		34.83		.08		35.13		.64	
2	.52		.16		.82		.08		.11		.64	
3	.51		.15		.81		.57		.09		.60	
4	.50		.15		.80		.72		.07		.60	
5	.48		.13		.78		36.05		.06		.60	
6	.47		.12		.79		.22		.04		.59	
7	.47		.11		.78		.27		.02		.58	
8	.45		.10		.76		.23		.01		.58	
9	.44		.09		.76		.15		34.99		.56	
10	.43		.07		.75		.05		.97		.56	
11	.43		.06		.75		35.94		.96		.56	
12	.42		.05		.75		.85		.91		.56	
13	.42		.05		.76		.77		.89		.56	
14	.41		.03		.80		.69		.87		.55	
15	.39		.02		.84		.63		.76		.54	
16	.38		.01		.84		.58		.73		.53	
17	.37		.00		.84		.54		.69		.53	
18	.35		34.99		.88		.50		.68		.52	
19	.33		.98		.94		.46		.67		.52	
20	.32		.97		35.00		.42		.66		.50	
21	.31		.95		.05		.40		.65		.50	
22	.30		.94		.08		.38		.73		.42	
23	.28		.94		.10		.35		.70		.43	
24	.25		.93		.12		.31		.68		.42	
25	.24		.91		.12		.29		.65		.40	
26	.24		.90		.13		.27		.65		.41	
27	.23		.88		.12		.24		.63		.40	
28	.22		.87		.12		.21		.62		.39	
29	.21		.87		.12		.19		.67		.39	
30	.21		.85		.11		.18		.66		.39	
31	.19				.09		.16				.38	

Remarks? B.P. 7/25 = 2335.12, 8/7 = 2336.27

Maximum for Period 2336.27 8/7 Minimum for Period 2334.37 10/30 Maximum Range 1.90
Observer: R. S. Pierce Recorder: R. S. Pierce Checked by: E. A. Johnson

Elevation of the water table above mean sea level is recorded unless otherwise shown by remarks. The figures for hundreds of feet are omitted. &ample, 2264.12 is recorded as 64.12.

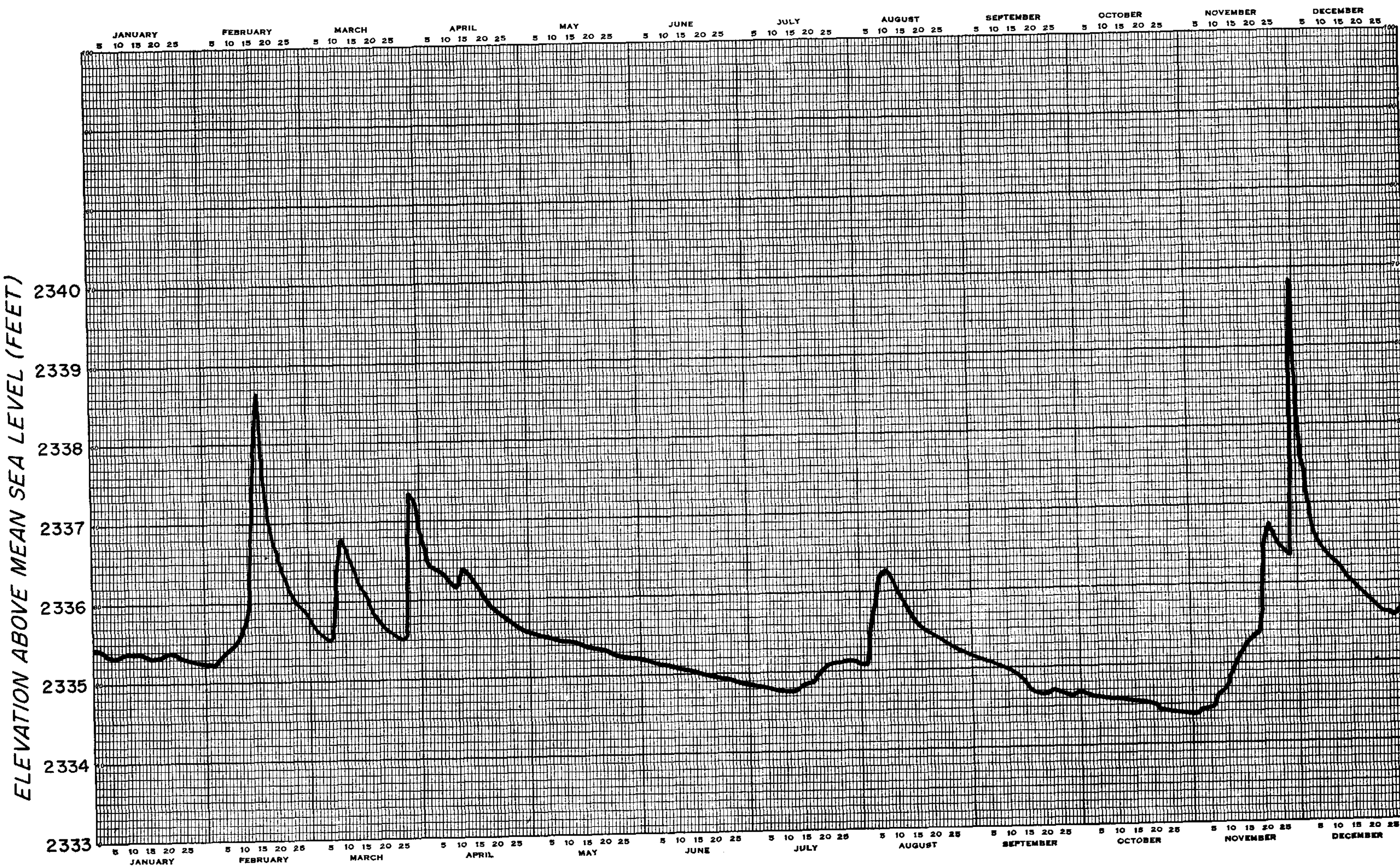

Figure 8. - - Water table elevations at 8 A. M. from Well No. 6 for 1948.

CONVERSION FACTORS

Area:

acres to square miles $= \frac{\text{Acres}}{640}$

Rate:

c.f.s. to c.s.m. $= \frac{\text{c.f.s.}}{\text{square mi.}}$ or $\frac{640}{\text{area}} \times$ c.f.s.

c.f.s. to in./hr. $= \left(\frac{3600}{43560 \times \text{acres}}\right) \times 12$

c.s.m. to in./hr. = c.s.m. $\left(\frac{3600}{43560 \times 640}\right) \times 12$

c.f.s. to a./f. per day = c.f.s. $\frac{(86400)}{43560}$

c.s.m. to depth per day (inches) = c.s.m. $\left(\frac{86400}{43560 \times 640}\right) \times 12$

Volume:

cu. ft. to cu. ft. per sq. mi. $= \frac{\text{cu.ft.}}{\text{sq.mi.}}$ or $\frac{640}{\text{area}} \times$ cu. ft.

cu. ft. to area inches = cu. ft. $\left(\frac{1}{43560 \times \text{acres}}\right) \times 12$

cu. ft. to mean daily c.s.m. = cu.ft. $\left(\frac{1}{86400 \times \text{sq. mi.}}\right)$

cu. ft. to a./f. $= \frac{\text{cu. ft.}}{43560}$

Agriculture--Asheville