Hydrologic Studies of Small Watersheds, Honey Creek Basin, Collin and Grayson Counties, Texas, 1953-59

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1779-F

Prepared in cooperation with the U.S. Soil Conservation Service and the Texas Water Commission

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By C. R. GILBERT, G. G. COMMONS, G. E. KOBERG, *and* F. W. KENNON

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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HYDROLOGIC STUDIES OF SMALL WATERSHEDS, HONEY CREEK BASIN, COLLIN AND GRAYSON COUNTIES, TEXAS, 1953-59

By C. R. GILBERT, G. G. COMMONS, G. E. KOBERG, and F. W. KENNON

ABSTRACT

This report presents the results of an investigation into the effects of floodwater-retarding structures in the 39 square miles of the Honey Creek basin above the stream-gaging station near McKinney, during the period October 1952 to September 1959. The number of such structures in the study area was increased from 2 to 12 during the investigation.

Data were collected which permit computation of basin and watershed precipitation, inflow to and outflow from each floodwater-retarding structure, evaporation and seepage from each pool, and a continuous record of discharge from the entire study area. Transpiration was not evaluated, but in the water-budget summary it is included in the item "pool consumption", together with evaporation and seepage.

During the 7-year study period, the annual inflow to the gaged pools ranged from 1.34 to 26.50 inches and averaged 7.39 inches, of which 0.73 inch was direct rainfall on the pool surface. The annual pool consumption ranged only from 1.33 to 1.85 inches, and averaged 1.62 inches. These results indicate that in a year of substantial runoff the floodwater-retarding structures would have only a minor effect on downstream water yield, but in a year of low runoff the structures would have a marked effect on downstream water yield.

The effect on the flood regimen at a downstream point because of floodwater-retarding structures in the headwaters will vary with the amount and intensity of the precipitation and with antecedent conditions. The beneficial effects of the structures on Honey Creek during the floods of April and May 1957 is illustrative. During the period April 19 to May 31, 1957, the total volume of inflow to the floodwater-retarding structures was equivalent to 4.3 times the combined capacities of the pools from an average basin rainfall of 30.31 inches. The retarding effects of the structures limited the flooding on Honey Creek at the gage to minor flooding on only five occasions during that period.

INTRODUCTION

Construction of floodwater-retarding structures in the Trinity River basin by the Soil Conservation Service began in 1950. The structures are designed to control floods in the upstream tributaries. Natural runoff is ponded above the structures and discharged at rates which lessen the peak rate of flow by prolonging the time of flow. Sediment and water are collected in a pool below the level of the uncontrolled outflow works. A portion of the inflowing sediment is trapped, thus reducing the turbidity of the water passing the structure. A portion of the inflowing water that is stored below the uncontrolled outlet is removed by evaporation, seepage, or transpiration. Thus the structures reduce the frequency of downstream flooding and to a lesser extent the total runoff of the basin.

In 1951 the Geological Survey in cooperation with the Soil Conservation Service and the Texas Board of Water Engineers (now Texas Water Commission) initiated investigations to study the effect of floodwater-retarding pools on runoff. The Soil Conservation Service conducts companion investigations to measure and appraise the amount of sediment trapped in the pools above the structures.

This report describes and gives results of an investigation of the hydrology of the Honey Creek basin, in which floodwater-retarding structures have been built. This basin is one of 11 in Texas now being investigated by the Geological Survey on a cooperative basis with the Soil Conservation Service, the Texas Water Commission, the Tarrant County Water Control and Improvement District No. 1, the San Antonio River Authority, and the city of Dallas. A tabulation of these basins is as follows:

Basin	*Drainage area above streamflow station (square miles)*
Trinity River basin:	
North Creek near Jacksboro	21.6
Elm Fork Trinity River near Muenster	46.0
Little Elm Creek near Aubrey	75.5
Honey Creek near McKinney	39.0
Pin Oak Creek near Hubbard	17.6
Brazos River basin:	
Green Creek near Alexander	45.5
Cow Bayou near Mooreville	79.6
Colorado River basin:	
Deep Creek near Mercury	43.9
Mukewater Creek near Trickham	70.4
San Antonio River basin:	
Calaveras Creek near Elmendorf	77.2
Escondido Creek at Kenedy	82.2

On four of the above basins—North, Little Elm, Pin Oak, and Mukewater Creeks—floodwater-retarding structures have not been built. Hydrologic data collection programs have been underway for several years, thus affording the opportunity for analyses of the "before and after" conditions of development.

PURPOSE AND SCOPE OF HYDROLOGIC STUDIES

The broad purpose of these investigations is to glean all the hydrologic and hydraulic analogies possible from the data collected. Specific objectives toward which these studies are directed are:

1. To obtain data from which the net effect of floodwater-retarding structures on the regimen of streamflow may be determined at downstream points. The effect of these structures on both the volume and rate of streamflow at downstream points is sought. As more and more structures are built, it becomes increasingly important that these effects be incorporated in the design of downstream water-supply developments and flood-control reservoirs.
2. To determine the effect of the structures on the underlying groundwater reservoir.
3. To determine the effect of the structures on the sediment yield of the basin and to determine the trap efficiency of the structures.
4. To develop computation techniques that will give more accurate estimates of runoff resulting from a given amount of rainfall on small watersheds.
5. To develop relations between maximum rates of runoff and rainfall in small watersheds that will enable more accurate design of small storm-drainage structures.
6. To develop or improve flood-routing procedures and techniques applicable to small watersheds.
7. To determine the minimum instrumentation necessary for making reliable estimates of total storm inflow to the structures.

PURPOSE AND SCOPE OF REPORT

The purpose of this report is to describe the investigation, to evaluate the adequacy of the data obtained, and to define the effects of the floodwater-retarding pools on the discharge from the watershed.[1]

The investigation on the Honey Creek basin began in 1951; results are reported here through 1959, though the field investigation is continuing. The number of floodwater-retarding structures in the study area increased from 2 in 1951 to 12 in 1957. Data were collected which permit computation of basin and watershed precipitation, inflow to and outflow from each floodwater-retarding pool, evaporation, and seepage as a residual from each pool, and a continuous record of discharge from the entire study area.

ACKNOWLEDGMENTS

The fieldwork was done by the engineering staffs of the Geological Survey subdistrict office in Fort Worth, Tex., J. H. Montgomery, engineer-in-charge; and the engineering staffs of the Soil Conservation

[1] Results of hydrologic studies of other watersheds will be placed on open file and will be available from the District Engineer, U.S. Geological Survey, Austin, Tex.

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Service office in McKinney, Tex., R. E. Lewis and H. W. Mayfield in charge.

The section of the report covering basin features, geography, and flood-control developments was prepared by G.G. Commons, engineer, Soil Conservation Service, Fort Worth, Tex.

The sections on evaporation and seepage were prepared by G. E. Koberg, engineer, Geological Survey, Denver, Colo., and F. W. Kennon, engineer, Geological Survey, Oklahoma City, Okla.

The compilation of the report and the preparation of the other sections of the report was made by C. R. Gilbert, engineer, Geological Survey, Fort Worth, Tex.

The financial cooperation of the Texas Board of Water Engineers (now Texas Water Commission), J. J. Vandertulip, chief engineer, is gratefully acknowledged.

The cooperation of H. O. Matson, Head, Engineering and Watershed Planning Unit, Soil Conservation Service, Fort Worth, Tex., and H. N. Smith, State conservationist, Soil Conservation Service, Temple, Tex.—who provided rainfall information, certain records of reservoir contents and land-use practices—was vital to the completion of this report.

This report was prepared under the direct supervision of Trigg Twichell, district engineer, Surface Water Branch, Geological Survey, Austin, Tex.

BASIN FEATURES, GEOGRAPHY, AND FLOOD-CONTROL DEVELOPMENTS

GENERAL DESCRIPTION

Honey Creek rises near Gunter in Grayson County, Tex., and flows about 15 miles in a southeasterly direction to its junction with the East Fork of the Trinity River near McKinney, in Collin County. Runoff from the basin flows through Lavon Reservoir on its way to the main Trinity River and finally empties into Trinity Bay of the Gulf of Mexico. The basin is rectangular in shape and has an average width of about 4 miles.

The total area of the basin is 32,421 acres, approximately 51 square miles. About 8 percent, or 2,420 acres, is in stream channels or flood plain subject to flooding. Approximately two-thirds of the basin is used for crop production, and most of the remainder is in pasture.

That portion of the basin investigated in this report comprises 39.0 square miles, approximately three-fourths of the total area of the basin. Figure 1 shows the location of the entire basin and the part under study.

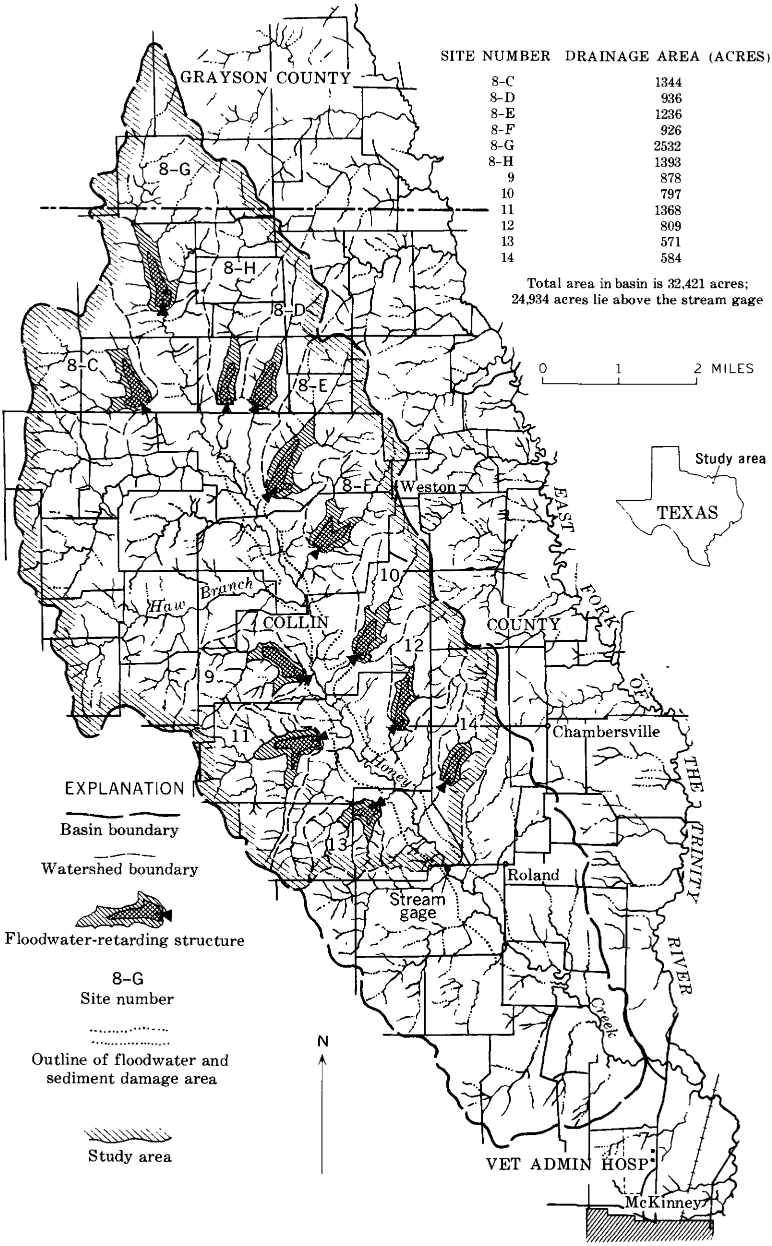

FIGURE 1.—Map of Honey Creek basin and study area, showing location of floodwater-retarding structures.

During the period 1920 to 1950, the population of Collin County decreased about 8,000, from an original 50,000. During the same time, the urban population in McKinney increased by 4,000, to a total of approximately 10,600. This exodus from farms reflects the mechanization of farming operations rather than the abandonment of cultivated land. Land which has been retired from cultivation to pasture generally has been marginal in production until recent years, when the trend has been to convert much of the better land to growing improved grasses for pasture. Considerable acreage also has been placed in conservation reserve under the existing agricultural stabilization program.

The annual rainfall at McKinney has ranged from 76.12 inches in 1877 to 20.76 inches in 1925, and the long-time yearly average is 39.24 inches. The range in annual rainfall during the period covered by this report (1953–59) was from 60.11 inches in 1957 to 22.34 inches in 1956. Temperatures have ranged from 118° to minus 7° F, the January mean being 44.7° and the August mean being 84.3° F. The average frost-free period of 230 days extends from March 20 to November 10. Tropical disturbances originating in the Gulf of Mexico often cause intense rainstorms on the basin. At other times, intense thundershowers are the cause of runoff, and slow, gentle rains are the exception rather than the rule.

Original settlers came to Collin County in the middle of the nineteenth century. In the post-Civil War period, the fertile blackland was used for cotton production and the area has been predominantly agricultural since that time. Because the soil is erodible, considerable deterioration had occurred by the mid-1930's. Since that time, erosion-control practices and soil-improving measures have been initiated, which have started the area toward recovery.

All geologic formations in this general blackland area are of Upper Cretaceous age. The Austin Chalk underlies all of the basin except for a narrow fringe of Eagle Ford Shale along the northwestern divide.

Soils in the basin have formed from chalks and marls, with a sprinkling of sands from thin sandstone ledges. Alluvial soils in the creek bottoms are formed from all sources and are very productive. Black waxy soils developed from marls (calcareous clays) are productive except where erosion has been severe. Other soils, lighter in color, are developed from interbedded parent materials.

The Austin Chalk supplies small quantities of hard water to shallow dug wells in the area. The water in the chalk occurs in fractures and minute crevices, which serve as channels for the percolation and movement of water downward and laterally. Because of the mode of occurrence of the ground water, the water levels in most of the shallow wells fluctuate directly with rainfall and many of the wells are dry for extended periods.

FLOOD-CONTROL DEVELOPMENTS

In addition to the usual land-treatment measures such as terracing, cover cropping, contour farming, and pasture improvement, floodwater-retarding structures and other flood-prevention measures were authorized under the Flood Control Act of December 22, 1944. A floodwater-retarding structure generally is an earthen dam controlling a storage basin which remains essentially empty except for short periods following storm runoff. The storage capacity normally ranges from the runoff to be expected from a 25-year frequency or 4-percent chance flood to the runoff from a 100-year frequency or 1-percent chance flood. The temporarily stored water is drained through an ungated conduit of such size that the discharge will not overflow the downstream channel. In all cases, the discharge rate will empty a full reservoir in a few weeks if no additional runoff is added. Emergency spillways provide for discharge of floodwater that exceeds the storage capacity of a structure. In addition, sediment storage capacity is provided for a 50- to 100-year period, thus assuring a fully effective life of that length of time for the structure.

Figure 1 gives the structure location and designation within the basin. Throughout the report the structure number is used to identify the structure on the corresponding pool. Sections of the type structures in the area of study are shown as figures 2 and 3. Pertinent information as to the capacity of the pool at each structure is given in table 1.

TABLE 1.—*Floodwater-retarding structure data, Honey Creek basin*

[All gages except those at sites 11 and 12 are staff gages read weekly]

Site	Drainage area (square miles)	Date dam completed	Date gage established	Design-storage data: Acre-feet: Sediment pool	Design-storage data: Acre-feet: Floodwater pool	Design-storage data: Acre-feet: Total	Design-storage data: Inches of runoff: Sediment pool	Design-storage data: Inches of runoff: Floodwater pool	Design-storage data: Inches of runoff: Total	Average flood-retarding time [1] (days)
8C	2.10	Sept. 1956	Mar. 1957	190	576	766	1.70	5.14	6.84	18.5
8D	1.46	July 1957	Nov. 1957	185	422	607	2.38	5.42	7.80	14
8E	1.93	July 1957	Nov. 1957	230	473	703	2.23	4.60	6.83	14.5
8F	1.45	July 1955	Sept. 1955	113	387	500	1.46	5.00	6.46	21
8G	3.96	July 1955	Sept. 1955	199	1,129	1,328	.94	5.35	6.29	29
8H	2.18	Sept. 1956	Mar. 1957	235	627	862	2.02	5.39	7.41	20
9	1.37	Dec. 1951	Dec. 1954	120	414	534	1.64	5.66	7.30	23
10	1.25	Jan. 1952	Mar. 1955	128	419	547	1.92	6.28	8.20	24
11	2.14	Feb. 1952	Sept. 1952 [2]	442	770	1,212	3.87	6.75	10.62	57
12	1.26	Jan. 1952	Sept. 1952 [2]	184	424	608	2.74	6.31	9.05	28
13	.89	Feb. 1952	Dec. 1954	159	287	446	3.35	6.05	9.40	28
14	.91	Aug. 1951	Dec. 1954	81	297	378	1.67	6.12	7.79	14.5
Total	20.90			2,266	6,225	8,491				

[1] Time required to drain a full floodwater-retarding pool with little or no inflow to the pool.
[2] Water-stage recorder on pool.

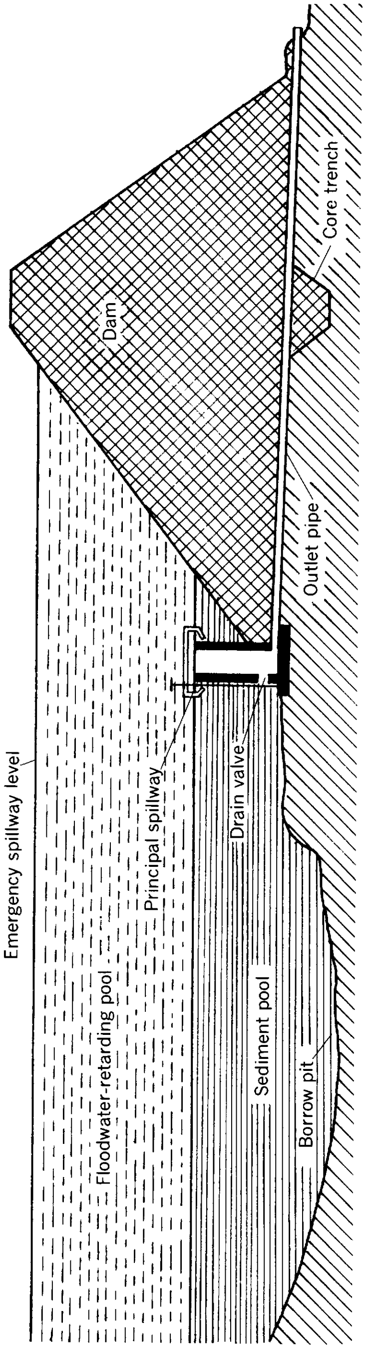

FIGURE 2.—Outlet works of the type at sites 8C, 8D, 8E, 8F, 8G, and 8H.

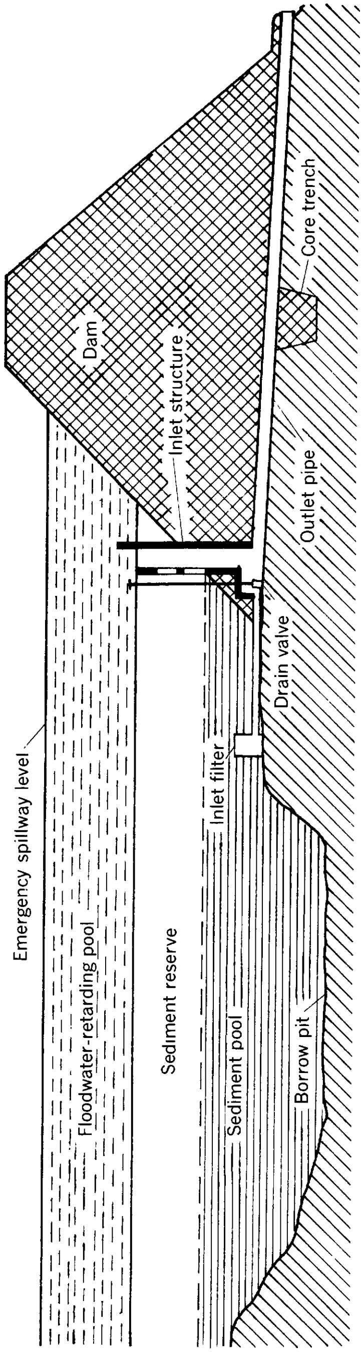

FIGURE 3.—Outlet works of the type at sites 9–14.

SECTIONS OF A TYPICAL FLOODWATER-RETARDING STRUCTURES.

DATA COLLECTION, PRESENTATION, AND ANALYSIS

RAINFALL

GAGES AND PERIOD OF RECORD

Rainfall in the 39.0-square-mile basin of study is measured by 14 U.S. Weather Bureau rain gages. Of these, 4 are recording and 10 are 8-inch nonrecording. All gages were installed in accordance with U.S. Weather Bureau procedures. The gages were located areally to afford the best geometrical coverage of the basin, with greater concentration near the two floodwater-retarding structures having water-level recorders (sites 11 and 12). The location and designation of each gage is shown in figure 4. The maximum distance between adjacent gages is about 2 miles and the minimum about 1 mile. The recording gages were installed on May 29, 1953, and the nonrecording gages on June 25, 1953. Gages are serviced and rainfall is measured weekly by a regular observer.

RECORDS

A tabulation of all the individual storm rainfall along with the monthly and annual totals for the period June 1953 to September 1959 is given in table 2.

For the purpose of this report a "storm" is defined as any period of rainfall, regardless of magnitude, separated in general by a minimum of 6 hours from the occurrence of other rainfall. As the nonrecording rain gages are serviced weekly and more than one storm is frequently represented by the week's yield, it is necessary to distribute this yield to separate storm periods. This distribution is made on the basis of the storm rainfall occurring at the nearest recording gage. The error in distributing the storm rainfall for the nonrecording gages by using this procedure is believed to be negligible.

AREAL DISTRIBUTION

The areal variability in storm rainfall distribution during the period covered by this report is evaluated by four simple graphical comparisons. In each of these comparisons the average storm rainfall as indicated by all 14 gages was plotted as the abscissa. The measured rainfall or average storm rainfall shown for the following gage or combination of gages was plotted as the ordinate: 9R; 5R and 12R; 6S and 7S; and 5R, 6S, 7S, and 12R. All storms occurring during the period which showed an average basin rainfall of 0.4 inch or more were plotted. There were 152 storm rainfalls selected on this basis. The first comparison, using gage 9R as the ordinate, is shown in figure 5. The comparison shows that two-thirds of the storm rainfalls measured at 9R are within about 16 percent of the mean rainfall based on all 14 gages.

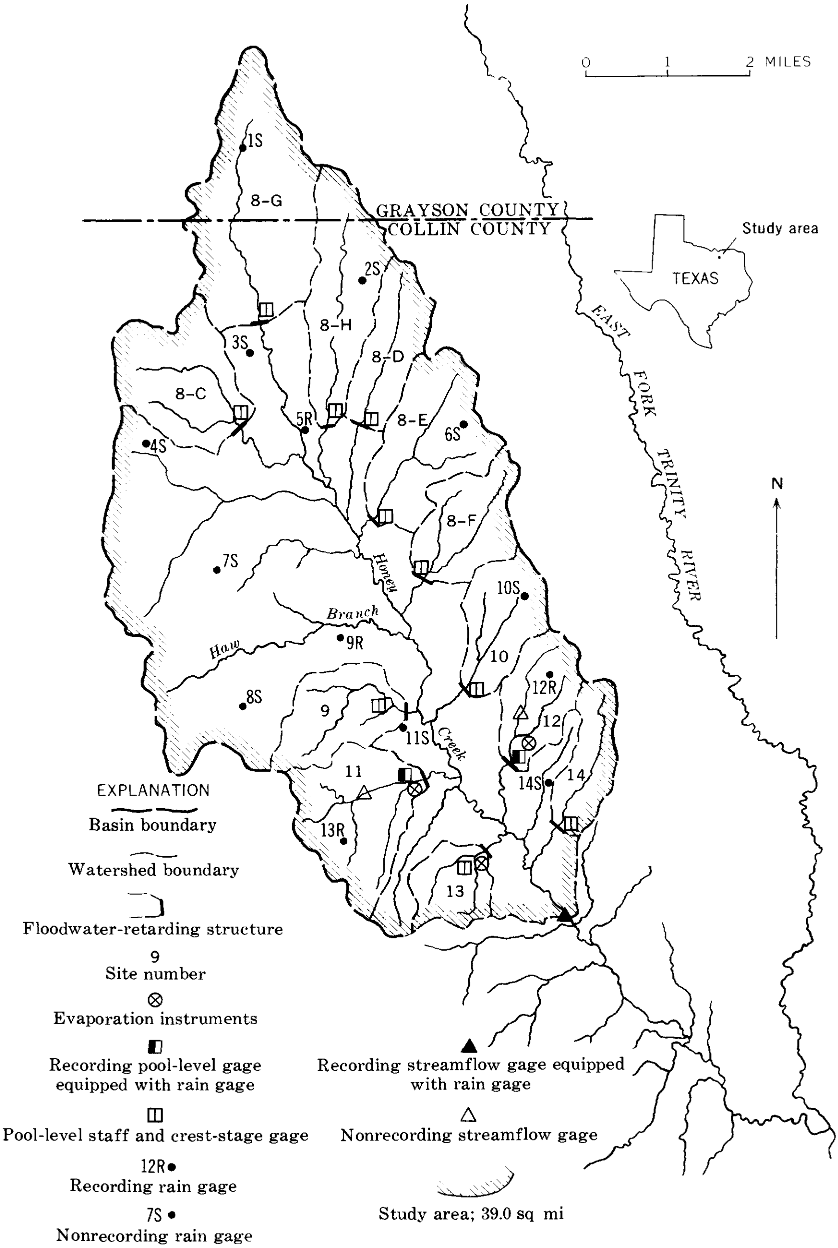

FIGURE 4.—Hydrologic instrument installations and designations, Honey Creek basin.

TABLE 2.—*Summary of rainfall, in inches, for Honey Creek basin, June 1953 to September 1959*

[Recording gages (R) installed May 29, 1953. Standard gages (S) installed June 25, 1953]

Date of storm	Gage No.													
	1S	2S	3S	4S	5R	6S	7S	8S	9R	10S	11S	12R	13R	14S
1953														
June 5	------	------	------	------	0.27	------	------	------	0	------	------	0	0	------
29	0.14	0.17	0.15	0.18	.22	0.17	0.23	0.23	0.22	0.23	0.21	0.32	0.32	0.25
July 8	0.19	0.17	0.15	0.21	0.20	0.18	0.25	0.23	0.25	0.24	0.18	0.20	0.05	0.18
12–13	1.07	1.01	.85	1.21	1.13	1.00	.78	.71	.78	.85	.57	.72	.95	.66
16–21	.94	.90	1.08	.78	.70	1.29	.70	.94	1.10	.94	2.28	2.20	1.55	2.19
Monthly total	2.30	2.08	2.08	2.20	2.03	2.47	1.73	1.88	2.13	2.03	3.03	3.12	2.55	3.03
August 7	0.05	0.10	0.07	0.04	0.10	0.09	0.09	0.08	0.09	0.42	0.10	0.30	0.10	0.35
12	.78	1.55	1.09	.67	1.45	1.44	1.18	1.10	1.20	1.12	1.39	.80	.90	.96
19	.23	.29	.19	.17	.20	.26	.12	.14	.15	.11	.18	.10	.21	.15
30	.58	.72	.45	.40	.48	.63	.50	.61	.65	.61	.79	.55	.70	.81
31	.12	.10	.11	.10	.10	.08	.08	.06	.05	.14	.10	.15	.25	.18
Monthly total	1.76	2.76	1.91	1.38	2.33	2.50	1.97	1.99	2.14	2.40	2.56	1.90	2.16	2.45
September 3	0.96	0.92	0.77	0.77	0.89	0.87	0.78	0.73	0.93	1.53	0.83	1.46	1.80	1.50
21	.61	.58	.54	.54	.56	.55	.73	.70	.90	.67	.80	1.15	.79	1.22
Monthly total	1.57	1.50	1.31	1.31	1.45	1.42	1.51	1.43	1.83	2.20	1.63	2.61	2.59	2.72
1953 Water year total	------	------	------	------	------	------	------	------	------	------	------	------	------	------
October 3	0.94	0.76	0.81	0.67	0.80	0.83	0.66	0.55	0.55	0.68	0.63	0.62	0.40	0.65
22–25	4.40	4.32	4.09	3.25	3.40	3.19	3.01	3.30	3.00	2.66	3.14	2.50	2.40	2.58
Monthly total	5.34	5.08	4.90	3.92	4.20	4.02	3.67	3.85	3.55	3.34	3.77	3.12	2.80	3.23
November 3–7	2.37	2.36	2.37	2.55	2.20	2.37	1.85	1.95	1.85	1.95	2.10	2.00	2.20	2.62
19	1.61	1.39	1.58	1.44	1.10	1.39	1.40	1.04	1.10	1.11	1.09	1.00	1.10	.97
Monthly total	3.98	3.75	3.95	3.99	3.30	3.76	3.25	2.99	2.95	3.06	3.19	3.00	3.30	3.59
December 2–3	0.80	0.89	0.79	0.83	0.90	0.72	0.90	0.36	1.05	0.87	1.05	1.05	1.25	0.87
11	.40	.37	.32	.31	.35	.38	.30	.34	.30	.46	.41	.50	.40	.55
27	.14	.18	.17	.15	.15	.15	.12	.12	.10	.12	.09	.10	.10	.09
Monthly total	1.34	1.44	1.28	1.29	1.40	1.25	1.32	0.82	1.45	1.45	1.55	1.65	1.75	1.51
1953 Calendar year total	------	------	------	------	------	------	------	------	------	------	------	------	------	------

TABLE 2.—*Summary of rainfall, in inches, for Honey Creek basin, June 1953 to September 1959*—Continued

[Recording gages (R) installed May 29, 1953. Standard gages (S) installed June 25, 1953]

Date of storm		Gage No.													
		1S	2S	3S	4S	5R	6S	7S	8S	9R	10S	11S	12R	13R	14S
	1954														
January	9	0.38	0.36	0.39	0.43	0.47	0.45	0.44	0.36	0.40	0.36	0.44	0.35	0.25	0.40
	13–14	1.46	1.57	1.54	1.57	1.70	1.54	1.55	1.54	1.35	1.32	1.33	1.30	1.35	1.13
	19–21	.21	.45	.80	.54	1.20	.61	.45	.59	.70	.42	.32	.60	.70	.41
	30	.06	.10	.07	.15	.10	.10	.21	.12	.10	.14	.15	.08	.10	.16
Monthly total		2.11	2.48	2.80	2.69	3.47	2.70	2.65	2.61	2.55	2.24	2.24	2.33	2.40	2.10
February	19	0.35	0.32	0.37	0.34	0.25	0.35	0.27	0.28	0.30	0.37	0.39	0.35	0.40	0.44
March	23	0.20	0.40	0.43	0.30	0.25	0.17	0.22	0.09	0.10	0.21	0.19	0.15	0.10	0.09
	24	.43	.50	.47	.51	.45	.46	.44	.44	.45	.46	.51	.50	.50	.36
Monthly total		0.63	0.90	0.90	0.81	0.70	0.63	0.66	0.53	0.55	0.67	0.70	0.65	0.60	0.45
April	11–13	1.91	2.67	3.21	2.77	3.25	3.34	3.02	2.95	2.70	2.20	2.78	2.70	2.90	2.53
	14	.50	.52	.54	.55	.55	.48	.67	.64	.60	.40	.30	.20	0	.24
	27–30	2.30	2.58	2.26	1.85	2.31	2.15	1.94	2.12	2.42	2.28	2.25	2.47	2.54	2.17
Monthly total		4.71	5.77	6.01	5.17	6.11	5.97	5.63	5.71	5.72	4.88	5.33	5.37	5.44	4.94
May	2	0.19	0.21	0.19	0.15	0.19	0.18	0.22	0.24	0.28	0.26	0.30	0.33	0.31	0.26
	10	1.65	1.61	1.58	1.54	1.50	1.53	1.40	1.84	1.50	1.47	1.59	1.60	1.65	1.71
	11–12	1.57	1.65	1.43	1.84	1.70	1.81	1.91	2.46	2.30	2.28	2.03	2.05	2.17	2.01
	25–27	1.77	1.29	1.42	1.37	1.00	1.80	1.75	1.97	2.25	2.22	1.26	1.30	1.00	1.36
Monthly total		5.18	4.76	4.62	4.90	4.39	5.32	5.28	6.51	6.33	6.23	5.18	5.28	5.13	5.34
June	2	0.48	0.52	0.57	0.53	0.65	0.51	0.74	0.72	0.50	0.45	0.54	0.45	0.70	0.63
	8	1.80	1.49	1.70	1.63	1.50	1.51	1.44	1.39	1.40	1.50	1.27	1.50	1.45	1.25
	15	2.15	2.05	2.05	1.86	1.75	1.32	1.05	2.15	1.85	1.42	1.54	2.00	2.10	1.90
	30	0	0	0	0	.10	.50	.25	.45	.50	.15	.18	.20	.55	.15
Monthly total		4.43	4.06	4.32	4.02	4.00	3.84	3.48	4.71	4.25	3.52	3.53	4.15	4.80	3.93
July	3	0	0	0	0	0	0.18	0.12	0.20	0.20	0.05	0.02	0	0.38	0.05
	14	.89	.63	.38	.27	.39	.32	.37	1.30	.80	.73	1.56	.90	1.23	1.17
	31	1.34	1.08	1.25	1.69	.98	.60	1.66	1.72	1.26	.66	1.34	.65	1.20	.55
Monthly total		2.23	1.71	1.63	1.96	1.37	1.10	2.15	3.22	2.26	1.44	2.92	1.55	2.81	1.77

August	9	0.12	0.10	0.09	0.11	0.10	0.09	0.16	0.21	0.19	0.16	0.19	0.18	0.22	0.16
	19	.38	.58	.71	.79	1.15	.36	.83	.70	.67	.37	.75	.65	.20	.99
	23	1.12	1.16	.76	.78	1.50	1.55	.77	.87	1.55	1.81	1.49	1.95	1.15	1.60
Monthly total		1.62	1.84	1.56	1.68	2.75	2.00	1.76	1.78	2.41	2.34	2.43	2.78	1.57	2.75
September	9	0.39	0.48	0.13	0.10	0.20	0.64	0.12	0.15	0.22	0.51	0.37	0.45	0.80	0.57
	20	.30	.39	.42	.22	.31	.39	.23	.24	.32	.54	.24	.35	.25	.28
	29–30	3.66	3.93	4.30	3.87	4.20	3.35	4.69	4.33	3.30	4.72	3.81	4.70	3.65	4.22
Monthly total		4.35	4.80	4.85	4.19	4.71	4.38	5.04	4.72	3.84	5.77	4.42	5.50	4.70	5.07
1954 Water year total		36.27	36.91	37.19	34.96	36.65	35.32	35.16	37.73	36.16	35.31	35.65	35.73	35.70	35.12
October	4	0.19	0.21	0.25	0.08	0.15	0.22	0.07	0.08	0.10	0.05	0.14	0.05	0.22	0.15
	11	.81	.57	.60	.52	.52	.45	.68	.62	.60	.57	.66	.45	.80	.32
	22–23	3.61	3.52	2.78	2.77	2.95	3.20	3.14	2.88	3.10	3.61	3.07	3.60	2.52	3.31
	26	.44	.46	.62	.87	.88	.96	.75	.85	.90	.89	.43	.50	.45	.48
Monthly total		5.05	4.76	4.25	4.24	4.50	4.83	4.64	4.43	4.70	5.12	4.30	4.60	3.99	4.26
November	2	0.74	0.76	0.74	0.72	0.70	0.71	0.72	0.75	0.75	0.80	0.81	0.85	0.90	0.86
	15	.03	.03	.04	.03	.04	.04	.06	.05	.05	.06	.07	.08	.08	.07
Monthly total		0.77	0.79	0.78	0.75	0.74	0.75	0.76	0.80	0.80	0.86	0.88	0.93	0.98	0.93
December	11–12	1.58	0.95	1.45	1.50	1.10	0.99	1.28	0.81	0.85	0.75	0.76	0.68	0.87	0.67
	28	.80	.81	.90	.87	.80	.76	.81	.70	.60	.64	.72	.55	.68	.59
Monthly total		2.38	1.76	2.35	2.37	1.90	1.75	2.09	1.51	1.45	1.39	1.48	1.23	1.55	1.26
1954 Calendar year total		33.81	33.95	34.44	33.12	34.89	33.62	34.41	36.81	35.16	34.83	33.80	34.72	34.37	33.24
	1955														
January	5–10	0.85	0.81	0.77	0.72	0.76	0.79	0.74	0.85	0.68	0.76	0.72	0.80	0.73	0.78
	14–15	.42	.37	.37	.36	.35	.37	.35	.35	.38	.36	.36	.35	.35	.35
	17–18	.65	.66	.85	.85	.85	.71	.93	.92	.90	.84	.76	.85	.80	.83
Monthly total		1.92	1.84	1.99	1.93	1.96	1.87	2.02	2.12	1.96	1.96	1.84	2.00	1.88	1.96
February	3–4	1.16	1.33	1.24	1.20	1.40	1.30	1.19	1.27	1.40	1.54	1.36	1.60	1.27	1.48
	18–19	1.51	2.06	2.02	1.98	2.00	2.11	1.97	1.79	1.95	1.54	1.57	1.40	1.55	1.09
	25	.03	.02	.02	.02	.03	.02	.03	.03	.03	.03	.04	.03	.03	.04
Monthly total		2.70	3.41	3.28	3.20	3.43	3.43	3.19	3.09	3.38	3.11	2.97	3.03	2.85	2.61
March	13	0.31	0.35	0.33	0.37	0.50	0.39	0.48	0.35	0.40	0.43	0.43	0.52	0.60	0.51
	18–21	1.78	1.85	1.95	1.87	1.52	1.71	1.41	1.73	2.00	1.80	1.73	1.70	1.83	1.91
	31	.78	.89	1.13	.98	.48	.13	.24	.09	.12	.57	.51	.65	.73	.55
Monthly total		2.87	3.09	3.41	3.22	2.50	2.23	2.13	2.17	2.52	2.80	2.67	2.87	3.16	2.97

TABLE 2.—*Summary of rainfall, in inches, for Honey Creek basin, June 1953 to September 1959*—Continued

[Recording gages (R) installed May 29, 1953. Standard gages (S) installed June 25, 1953]

Date of storm		Gage No.													
		1S	2S	3S	4S	5R	6S	7S	8S	9R	10S	11S	12R	13R	14S
	1955														
April	9	1.40	1.07	1.03	1.02	1.00	1.07	1.01	0.88	0.90	1.00	0.88	0.95	0.90	0.92
	12	.31	.29	.32	.27	.33	.40	.37	.29	.40	.44	.39	.55	.46	.45
	23	.25	.11	.14	.12	.20	.26	.23	.18	.20	.22	.15	.25	.15	.22
	28–29	.92	.65	.64	.37	.45	.25	.26	.13	.22	.40	.12	.25	.08	.29
Monthly total		2.88	2.12	2.13	1.78	1.98	1.98	1.87	1.48	1.72	2.06	1.54	2.00	1.59	1.88
May	10–11	1.17	0.77	0.67	0.70	0.48	0.86	0.97	1.21	1.43	1.29	0.95	0.75	1.10	0.83
	11	.24	.16	.14	.15	.10	.18	.10	.13	.15	.14	.17	.13	.14	.10
	15	1.00	.66	.57	.60	.41	.74	.37	.46	.55	.50	.41	.32	1.10	.83
	16	.83	.55	.47	.50	.34	.61	.35	.44	.52	.46	1.29	1.02	.50	.38
	18–19	1.38	1.28	1.27	1.51	1.30	1.69	1.51	1.89	1.37	2.04	1.28	1.22	1.36	1.31
	20	.23	.22	.22	.25	.22	.29	.28	.35	.25	.35	.30	.29	.33	.32
	26	1.17	.76	1.00	.80	.70	.61	.82	.75	.70	.59	.57	.50	.65	.38
Monthly total		6.02	4.40	4.34	4.51	3.55	4.98	4.40	5.23	4.97	5.37	4.97	4.23	5.18	4.15
June	4–5	0.33	0.42	0.38	0.38	0.47	0.47	0.43	0.40	0.42	0.42	0.41	0.45	0.43	0.40
	8	.10	.11	.11	.12	.12	.11	.14	.15	.12	.13	.13	.11	.16	.14
	16	1.29	1.46	1.12	1.11	1.30	1.24	.92	.73	.79	.93	.63	.70	.60	.61
	18	1.42	1.60	1.23	1.22	1.43	1.37	1.20	.95	1.03	1.21	1.13	1.26	1.24	1.27
	19	.06	.07	.06	.06	.06	.06	.10	.08	.08	.10	.03	.03	.05	.05
	23	0	0	0	0	.10	0	0	0	0	0	0	0	0	0
Monthly total		3.20	3.66	2.90	2.89	3.48	3.25	2.79	2.31	2.44	2.79	2.33	2.55	2.48	2.47
July	17	1.44	0.72	0.89	0.99	0.88	1.30	0.66	0.72	1.30	1.38	1.05	1.10	0.70	0.75
	18–19	0	0	0	0	0	0	0	0	0	0	0	0	.64	0
Monthly total		1.44	0.72	0.89	0.99	0.88	1.30	0.66	0.72	1.30	1.38	1.05	1.10	1.34	0.75
August	3	0.08	0.12	0.20	0.22	0.23	0.20	0.14	0.12	0.08	0.12	0.15	0.20	0.05	0.08
	28	0	0	0	0	.08	0	0	0	0	0	0	0	0	0
	30	1.37	.57	.62	.79	.37	.47	.32	.33	.15	.09	.23	.15	.30	.23
Monthly total		1.45	0.69	0.82	1.01	0.68	0.67	0.46	0.45	0.23	0.21	0.38	0.35	0.35	0.31
September	9–10	0.19	0.11	0.14	0.14	0.13	0.41	0.15	0.26	0.53	0.77	1.06	0.62	1.75	0.28
	15	0	0	.12	.01	.14	0	.03	0	.30	.13	.12	.25	0	.26
	22–23	.70	.52	.65	.70	.67	.57	1.26	.89	.86	.92	1.07	1.02	1.42	1.41
	23	.11	.07	.10	.10	.10	.09	0	0	0	0	0	0	.08	.08

24–25	.80	.60	.74	.80	.77	.66	.64	.46	.44	.47	.49	.47	.31	.31
26	.16	.23	.31	.18	.42	.33	.40	.83	.70	.70	.65	.45	1.94	.93
30	.54	.76	1.05	.59	1.40	1.08	.25	.51	.43	.43	1.19	.83	1.55	.74
Monthly total	2.50	2.29	3.11	2.52	3.63	3.14	2.73	2.95	3.26	3.42	4.58	3.64	7.05	4.01
1955 Water year total	33.18	29.53	30.25	29.41	29.23	30.18	27.74	27.26	28.73	30.47	28.99	28.53	32.40	27.56
October 6	0.66	0.55	0.71	0.62	0.53	0.38	0.53	0.32	0.37	0.32	0.47	0.38	0.78	0.49
27	.32	.09	.12	.13	.17	.09	.17	.11	.20	.17	.18	.12	.20	.07
Monthly total	0.98	0.64	0.83	0.75	0.70	0.47	0.70	0.43	0.57	0.49	0.65	0.50	0.98	0.56
November 30	0.60	0.59	0.55	0.61	0.63	0.61	0.57	0.61	0.57	0.61	0.57	0.63	0.61	0.62
December 1	0.21	0.21	0.20	0.21	0.22	0.22	0.20	0.21	0.23	0.22	0.20	0.22	0.19	0.22
1955 Calendar year total	26.77	23.66	24.45	23.62	23.64	24.15	21.72	21.77	23.15	24.42	23.75	23.12	27.66	22.51
1956														
January 17–18	0.06	0.07	0.07	0.06	0.07	0.07	0.07	0.08	0.07	0.07	0.08	0.08	0.05	0.08
19	.28	.29	.29	.28	.35	.30	.28	.34	.23	.30	.26	.31	.28	.40
20–21	.08	.09	.09	.08	.10	.09	.09	.10	.10	.10	.09	.10	.10	.10
21–22	.56	.56	.56	.55	.69	.57	.44	.52	.40	.46	.39	.45	.37	.49
Monthly total	0.98	1.01	1.01	0.97	1.21	1.03	0.88	1.04	0.80	0.93	0.82	0.94	0.80	1.07
February 1–2	0.50	0.84	0.67	0.64	1.10	0.75	0.75	0.78	0.80	1.01	1.09	1.00	1.05	1.08
8	.76	.67	.72	.75	.80	.63	.73	.72	.75	.63	.66	.75	.72	.70
15–16	.93	1.55	1.64	1.66	1.86	1.96	1.53	1.80	1.81	1.76	1.50	1.60	1.47	1.19
17	.46	.76	.80	.81	.91	.96	1.24	1.47	1.47	1.43	1.79	1.91	1.93	1.57
19	.04	.06	.07	.08	.08	.08	.08	.09	.09	.08	.10	.10	.11	.09
Monthly total	2.69	3.88	3.90	3.94	4.75	4.38	4.33	4.86	4.92	4.91	5.14	5.36	5.28	4.63
March 13	0.13	0.20	0.18	0.23	0.23	0.28	0.27	0.31	0.28	0.28	0.31	0.31	0.37	0.37
23	.10	.08	.09	.02	.07	.05	.06	.07	.11	.10	.06	.09	.06	.06
Monthly total	0.23	0.28	0.27	0.25	0.30	0.33	0.33	0.38	0.39	0.38	0.37	0.40	0.43	0.43
April 2	0.04	0.02	0.08	0.05	0.07	0.03	0.04	0.06	0.06	0.06	0.06	0.10	0.10	0.11
14	1.19	1.24	.74	.47	.49	.28	.08	.02	.06	.06	.02	0	0	.04
21	.22	.26	.28	.23	.26	.26	.24	.25	.24	.23	.22	.22	.23	.22
29–30	1.34	1.82	1.67	1.78	1.99	1.52	1.83	1.64	1.40	1.59	1.69	1.70	1.56	1.58
Monthly total	2.79	3.34	2.77	2.53	2.81	2.09	2.19	1.97	1.76	1.94	1.99	2.02	1.89	1.95

TABLE 2.—*Summary of rainfall, in inches, for Honey Creek basin, June 1953 to September 1959*—Continued

[Recording gages (R) installed May 29, 1953. Standard gages (S) installed June 25, 1953]

Date of storm		Gage No.													
		1S	2S	3S	4S	5R	6S	7S	8S	9R	10S	11S	12R	13R	14S
	1956														
May	1	2.43	2.24	1.98	2.00	2.11	2.10	1.70	1.64	1.65	1.80	1.77	1.90	1.68	2.08
	15	.50	.42	.43	.44	.50	.42	.46	.30	.30	.26	.22	.23	.21	.20
	23–24	.46	.30	.19	.11	.47	.64	.17	.40	.49	.36	.15	.20	.38	.33
	27	.02	.02	.01	.01	.03	.04	.05	.10	.13	.10	.30	.39	.17	.15
	30	1.15	.92	.83	.82	1.00	.86	.52	.56	.86	.75	.68	.97	.53	.70
Monthly total		4.56	3.90	3.44	3.38	4.11	4.06	2.90	3.00	3.43	3.27	3.12	3.69	2.97	3.46
June	8	0.19	0.22	0.13	0.08	0.16	0.36	0.10	0.26	0.33	0.45	0.21	0.35	1.30	0.42
July	6	0.11	0.11	0.12	0.08	0.08	0.08	0.14	0.07	0.05	0.09	0.11	0.60	0.06	0.05
	8	.90	.97	.99	.72	.68	.67	.54	.29	.20	.36	.03	.19	.38	.32
	23	.09	.10	.06	.10	.10	.04	.28	.55	.08	.09	.18	.05	.04	.01
	29	.20	.24	.14	.23	.23	.08	.25	.48	.07	.08	.18	.05	.63	.12
Monthly total		1.30	1.42	1.31	1.13	1.09	0.87	1.21	1.39	0.40	0.62	0.50	0.89	1.11	0.50
August	30	0.16	0.45	0.50	0.53	0.58	0.38	0.54	0.42	0.92	0.45	0.44	0.45	0.52	0.49
September	5	0.05	0.05	0.06	0.19	0.19	0.16	0.52	0.58	0.60	0.98	0.47	0.67	0.30	0.29
1956 Water year total		14.74	15.99	14.97	14.57	16.75	14.96	14.47	15.15	14.92	15.25	14.48	16.12	16.38	14.64
October	1	0.42	0.67	0.69	0.55	0.66	0.71	0.59	0.55	0.52	0.79	0.58	0.75	0.46	0.70
	14	.79	.65	.71	.72	.59	.63	.78	.61	.55	.66	.68	.73	.81	.84
	15–16	.10	.08	.09	.08	.10	.09	.20	.22	.17	.14	.09	.08	.10	.07
	18	.74	.62	.74	.65	.78	.68	.83	.95	.72	.59	.60	.50	.83	.60
	30	1.01	1.05	1.03	1.08	.85	1.02	1.06	1.03	.76	.90	.96	.82	.83	.94
Monthly total		3.06	3.07	3.26	3.08	2.98	3.13	3.46	3.36	2.72	3.08	2.91	2.88	3.03	3.15
November	2–4	2.95	3.08	3.04	3.16	3.54	2.99	3.13	3.02	3.27	2.63	2.80	2.93	3.17	2.75
	20	.05	.08	.12	.16	.18	.22	.30	.40	.48	.45	.35	.36	.40	.38
Monthly total		3.00	3.16	3.16	3.32	3.72	3.21	3.43	3.42	3.75	3.08	3.15	3.29	3.57	3.13
December	6	0.02	0.05	0.07	0.07	0.08	0.03	0.05	0.03	0.05	0.06	0.05	0.08	0.07	0.16
	18–19	2.50	2.00	2.08	2.32	2.18	2.14	2.23	2.27	2.07	1.93	1.90	1.95	1.95	1.90
	22	0	0	0	0	0	.03	0	.03	.01	.03	.04	0	.02	.05
Monthly total		2.52	2.05	2.15	2.39	2.26	2.20	2.28	2.33	2.13	2.02	1.99	2.03	2.04	2.11
1956 Calendar year total		21.53	22.83	21.96	21.79	24.16	22.20	22.17	23.01	22.15	22.11	21.11	22.97	23.24	21.63
	1957														
January	4	0.98	0.66	0.71	0.75	0.70	0.76	0.57	0.67	0.61	0.55	0.56	0.50	0.57	0.59

	18	.03	.03	.01	.02	.02	.01	0	0	0	0	0	0	0	.01
	27–28	.49	.54	.47	.57	.45	.40	.34	.40	.45	.56	.63	.58	.59	.63
	30–31	.98	.99	1.01	1.07	1.10	1.19	1.11	1.29	1.30	1.37	1.35	1.21	1.10	1.05
Monthly total		2.48	2.22	2.20	2.41	2.27	2.36	2.02	2.36	2.36	2.48	2.54	2.29	2.26	2.28
February	5–6	1.07	1.00	1.13	1.35	1.30	1.13	1.16	0.86	0.85	1.13	0.92	1.20	0.85	1.23
	18	.30	.31	.29	.30	.32	.31	.30	.33	.33	.32	.29	.32	.30	.30
	22	.53	.50	.51	.53	.52	.53	.53	.52	.47	.49	.47	.42	.41	.41
	24	.09	.07	.08	.10	.08	.10	.06	.06	.05	.06	.09	.08	.11	.11
Montly total		1.99	1.88	2.01	2.28	2.22	2.07	2.05	1.77	1.70	2.00	1.77	2.02	1.67	2.05
March	2	1.07	0.93	0.88	1.11	1.21	1.22	1.13	1.02	1.12	1.02	1.12	1.12	0.95	0.95
	17	1.48	1.47	1.37	1.41	1.61	1.77	1.30	1.44	1.52	1.65	1.34	1.31	1.12	1.04
	20	.65	.57	.58	.68	.70	.70	.66	.85	.70	.74	.73	.70	.65	.82
	23	.18	.16	.17	.20	.20	.20	.10	.13	.11	.12	.12	.12	.18	.23
	27	.85	.88	.82	.91	.87	.90	.80	.87	.72	.59	.60	.55	.41	.34
	30	.75	.77	.72	.80	.76	.78	.88	.98	.80	.66	.65	.60	.60	.50
	31	1.10	1.13	1.06	1.17	1.12	1.15	1.49	1.65	1.35	1.10	1.30	1.20	1.89	1.56
Monthly total		6.08	5.91	5.60	6.28	6.47	6.72	6.36	6.94	6.32	5.88	5.86	5.60	5.80	5.44
April	2–3	0.65	0.51	0.62	0.51	0.55	0.47	0.73	0.50	0.40	0.42	0.51	0.35	0.50	0.32
	12	.04	.02	.01	.04	.02	.02	.02	.02	.02	.02	.02	.02	.02	.04
	18	.27	.30	.30	.28	.32	.28	.12	.12	.10	.11	.17	.20	.22	.26
	19	3.55	3.96	3.93	3.70	4.18	3.70	4.03	3.99	3.40	3.64	3.57	4.18	3.09	3.62
	20–21	1.31	1.46	1.45	1.36	1.54	1.36	1.72	1.70	1.45	1.55	.96	1.12	1.28	1.50
	21	.07	.08	.07	.07	.08	.08	.08	.08	.07	.08	.08	.10	.07	.07
	23	2.37	2.17	1.95	2.11	1.96	2.13	1.86	1.86	1.94	2.10	2.21	2.40	1.84	2.18
	24	1.04	.95	.85	.92	.86	.93	.98	.98	1.02	1.10	1.24	1.35	1.30	1.54
	25–26	4.59	4.21	3.77	4.08	3.80	4.13	3.04	3.04	3.16	3.42	3.13	3.40	3.00	3.55
	28–29	.46	.42	.38	.41	.39	.41	.42	.42	.44	.48	.26	.27	.40	.47
	29–30	.40	.52	.64	.65	.76	.64	.38	.41	.39	.27	.40	.32	.82	.50
Monthly total		14.75	14.60	13.97	14.13	14.46	14.15	13.38	13.12	12.39	13.19	12.55	13.71	12.54	14.05
May	1	0.14	0.17	0.22	0.22	0.26	0.21	0.27	0.30	0.28	0.19	0.07	0.06	0.38	0.24
	3	.68	.89	1.09	1.12	1.30	1.09	1.85	2.00	1.89	1.31	1.45	1.16	.80	.49
	8	.12	.10	.10	.08	.10	.07	.09	.07	.08	.07	.06	.04	.10	.06
	9	.65	.55	.63	.55	.61	.45	.43	40	.39	.31	.31	.22	.36	.24
	12	1.18	.99	1.12	.98	1.09	.80	1.21	1.12	1.10	.88	1.12	.80	1.25	.84
	13	2.44	2.05	2.33	2.02	2.26	1.66	1.92	1.77	1.74	1.39	1.86	1.33	1.76	1.18
	15	.15	.14	.16	.15	.15	.14	.11	.11	.08	.13	.46	.60	.14	.19
	16	.41	.40	.43	.41	.42	.41	.15	.14	.10	.16	.29	.38	.36	.49
	18	1.15	1.10	1.21	1.16	1.17	1.13	1.32	1.24	.90	1.44	.63	.82	.76	1.04
	21	2.71	2.85	2.79	2.94	3.13	3.28	3.69	3.92	4.00	4.26	3.35	3.70	2.68	2.94
	22	.59	.62	.61	.64	.68	.71	.37	.39	.40	.43	.63	.70	.76	.82
	23	1.47	1.55	1.52	1.60	1.70	1.78	1.47	1.57	1.60	1.70	1.54	1.70	1.62	1.78
	25	2.78	2.91	2.85	3.00	3.20	3.36	2.86	3.04	3.10	3.30	3.44	3.80	3.17	3.48
	26	1.67	1.75	1.71	1.80	1.92	2.02	1.57	1.67	1.70	1.81	2.18	2.40	1.62	1.79
	30	.31	.22	.30	.23	.30	.13	.28	.25	.22	.24	.26	.18	.22	.18
	31	.24	.17	.23	.18	.23	.10	.34	.30	.27	.29	.29	.19	.34	.28
Monthly total		16.69	16.46	17.30	17.08	18.52	17.34	17.93	18.29	17.85	17.91	17.94	18.08	16.32	16.04

TABLE 2.—*Summary of rainfall, in inches, for Honey Creek basin, June 1953 to September 1959*—Continued

[Recording gages (R) installed May 29, 1953. Standard gages (S) installed June 25, 1953]

Date of storm		Gage No.													
		1S	2S	3S	4S	5R	6S	7S	8S	9R	10S	11S	12R	13R	14S
	1957														
June	2	0.18	0.12	0.17	0.13	0.17	0.07	0	0	0	0	0	0	0	0
	3	.18	.13	.17	.13	.17	.08	.07	.06	.05	.05	0	0	0	0
	4	.29	.20	.17	.16	.15	.18	.12	.20	.18	20	.23	.21	.18	.22
	10	0	0	.03	0	.10	.11	0	.08	.12	.09	.10	.13	.10	.15
	23	.07	.12	.24	.10	.25	.44	.06	.08	.18	1.03	.22	.75	.19	.52
Monthly total		0.72	0.57	0.78	0.52	0.84	0.88	0.25	0.42	0.53	1.37	0.55	1.09	0.47	0.89
July	20	0.04	0.05	0.28	0.40	0.20	0.10	0.11	0	0	0	0	0	0	0
	24	1.15	.11	.43	1.10	.60	.29	.43	.99	.05	.04	.04	.08	.20	.13
Monthly total		1.19	0.16	0.71	1.50	0.80	0.39	0.54	0.99	0.05	0.04	0.04	0.08	0.20	0.13
August	12	0.08	0.07	0.08	0.08	0.07	0.05	0.05	0.04	0.04	0.04	0.05	0.03	0.03	0.04
	19	.25	.13	.05	.13	.08	.10	.30	.09	.08	.09	.07	.10	0	.18
	31	0	0	0	0	0	0	.01	.03	.03	.02	.11	.06	.30	.27
Monthly total		0.33	0.20	0.13	0.21	0.15	0.15	0.36	0.16	0.15	0.15	0.23	0.20	0.33	0.49
September	2	0.13	0.05	0.13	0.33	0.17	0.11	0.05	0.20	0.20	0.08	0.31	0.17	0.16	0.14
	6–7	2.42	1.82	1.89	1.63	1.55	1.35	1.79	1.75	1.45	1.30	1.13	.95	1.11	.97
	11	1.00	1.13	1.25	1.22	1.01	.69	1.27	1.20	.83	.85	.71	1.00	.71	1.19
	21–22	2.71	2.96	2.90	3.00	2.79	3.03	2.68	2.73	2.81	2.38	2.21	2.34	2.11	2.50
Monthly total		6.26	5.96	6.17	6.18	5.52	5.18	5.79	5.88	5.29	4.61	4.36	4.46	4.09	4.80
1957 Water year total		59.07	56.24	57.44	59.38	60.21	57.78	57.85	59.04	55.24	55.81	53.89	55.73	52.32	54.56
October	8	0.17	0.15	0.17	0.17	0.18	0.16	0.15	0.17	0.16	0.12	0.15	0.11	0.18	0.09
	13	1.70	1.62	1.65	1.78	1.73	1.81	1.80	1.85	1.85	1.74	1.67	1.83	1.68	1.51
	14–15	.23	.27	.25	.26	.37	.30	.25	.27	.40	.33	.54	.44	.60	.62
	21–23	.50	.44	.40	.35	.54	.60	.48	.46	.59	.58	.52	.60	.66	.66
Monthly total		2.60	2.48	2.47	2.56	2.82	2.87	2.68	2.75	3.00	2.77	2.88	2.98	3.12	2.88
November	3–5	5.18	4.84	4.48	4.84	5.14	5.08	4.43	5.12	4.81	4.94	4.88	5.25	4.95	5.23
	7	.84	.87	.80	.78	.84	.66	.68	.64	.52	.77	.76	.82	.80	.70
	12	.16	.18	.15	.15	.16	.11	.17	.15	.16	.20	.20	.10	.20	.19
	17	.94	.52	.67	.79	.46	.73	.51	.73	.78	.82	.80	.84	1.03	1.14
	22	.09	.09	.10	.10	.10	.11	.08	.10	.08	.08	.10	.10	.10	.11
	24	.68	.69	.74	.73	.70	.73	.73	.74	.75	.72	.72	.71	.71	.73

Monthly total	7.89	7.19	6.94	7.39	7.40	7.42	6.60	7.48	7.10	7.53	7.46	7.82	7.79	8.10
December 6	0.55	0.58	0.60	0.56	0.63	0.65	0.64	0.66	0.61	0.66	0.62	0.59	0.62	0.66
24–25	1.05	1.06	1.05	1.09	1.05	1.15	1.10	1.07	1.05	1.07	1.12	1.15	1.18	1.26
Monthly total	1.60	1.64	1.65	1.65	1.68	1.80	1.74	1.73	1.66	1.73	1.74	1.74	1.80	1.92
1957 Calendar year total	62.58	59.27	59.93	62.19	63.15	61.33	59.70	61.89	58.40	59.66	57.92	60.07	56.39	59.07
1958														
January 12	0.93	0.82	0.90	0.94	0.95	0.90	0.70	0.90	0.90	1.18	1.08	1.04	1.21	1.08
19–20	.87	1.06	.90	1.05	1.04	.91	.82	.89	.84	.92	.84	.91	.74	.73
26	0	0	0	0	0	.01	0	.01	0	.04	.04	.01	.07	.11
28	.18	.12	.43	.28	.22	.14	.06	.13	.09	.09	.10	.10	.11	.12
Monthly total	1.98	2.00	2.23	2.27	2.21	1.96	1.58	1.93	1.83	2.23	2.06	2.06	2.13	2.04
February 9	0.09	0.07	0.09	0.12	0.13	0.11	0.10	0.12	0.11	0.10	0.08	0.09	0.09	0.12
14	.18	.30	.27	.29	.35	.39	.35	.45	.41	.40	.39	.39	.35	.40
26	.53	.36	.33	.31	.45	.18	.09	.17	.15	.20	.21	.20	.23	.22
Monthly total	0.80	0.73	0.69	0.72	0.93	0.68	0.54	0.74	0.67	0.70	0.68	0.68	0.67	0.74
March 4–8	1.42	1.37	1.45	1.65	1.46	1.45	1.46	1.41	1.32	1.69	1.70	1.97	1.80	2.04
12	.66	.70	.66	.71	.65	.66	.65	.65	.58	.63	.64	.58	.58	.71
22	.45	.38	.44	.45	.52	.55	.52	.54	.40	.33	.27	.25	.24	.26
27	.15	.17	.20	.21	.18	.15	.18	.20	.18	.20	.24	.13	.24	.25
28–29	.66	.75	.80	.80	.70	.65	.72	.79	.67	.72	.88	.83	1.00	1.00
Monthly total	3.35	3.37	3.55	3.82	3.51	3.46	3.53	3.59	3.15	3.57	3.73	3.76	3.86	4.26
April 4	0.32	0.29	0.25	0.25	0.30	0.38	0.38	0.26	0.30	0.33	0.30	0.57	0.26	0.30
8	.76	.59	.61	.62	.55	.70	.70	.72	.66	.70	.75	.78	.86	.75
13	.82	.64	.66	.68	.80	.75	.75	.77	.76	.76	.82	.78	.75	.81
17–18	.09	.09	.09	.09	.10	.09	.09	.08	0	.09	.09	.10	.10	.08
20	.41	.41	.41	.40	.36	.39	.41	.38	.44	.43	.39	.50	.38	.34
25–26	1.95	2.59	2.35	1.13	1.25	1.43	1.25	1.63	1.64	1.65	1.50	1.71	1.64	2.03
28–29	1.88	1.75	1.80	2.43	1.60	3.63	2.44	3.50	2.86	2.30	2.53	2.40	1.84	1.95
30	2.30	2.24	2.23	3.10	2.14	2.40	2.25	3.05	2.42	2.03	2.30	2.27	2.42	2.60
Monthly total	8.53	8.60	8.40	8.70	7.10	9.77	8.27	10.39	9.08	8.29	8.68	9.11	8.25	8.86
May 1	0.06	0.06	0.06	0.08	0.11	0.09	0.07	0.10	0.08	0.07	0.07	0.07	0.05	0.05
1–3	.56	.65	.73	.77	2.52	.82	2.59	.99	2.94	2.42	2.84	2.41	3.04	2.55
13–14	.24	.08	.30	.36	.22	.10	.40	.39	.30	.15	.20	.10	.21	.24
25	.53	.37	.31	.29	.26	.27	.29	.33	.34	.32	.31	.36	.31	.48
28	.06	.04	.04	.03	.10	.06	.02	0	0	0	.06	.20	0	.34
Monthly total	1.45	1.20	1.44	1.53	3.21	1.34	3.37	1.81	3.66	2.96	3.48	3.14	3.61	3.68

TABLE 2.—*Summary of rainfall, in inches, for Honey Creek basin, June 1953 to September 1959*—Continued

[Recording gages (R) installed May 29, 1953. Standard gages (S) installed June 25, 1953]

Date of storm		Gage No.													
		1S	2S	3S	4S	5R	6S	7S	8S	9R	10S	11S	12R	13R	14S
	1958														
June	5	0.22	0.28	0	0	0	0.08	0	0	0	0	0.05	0	0	0.06
	15–16	4.86	3.40	2.15	1.00	.94	.88	.95	.31	.21	.44	.63	.81	.43	.77
	20–21	1.57	1.50	1.71	1.20	1.43	1.30	1.44	1.61	1.69	1.51	1.28	1.23	.99	1.23
	24–26	.27	.22	.33	.35	.35	.39	.43	.42	.41	.36	.33	.36	.38	.28
Monthly total		6.92	5.40	4.19	2.55	2.72	2.65	2.82	2.34	2.31	2.31	2.29	2.40	1.80	2.34
July	4–6	0.86	0.98	0.84	0.83	0.79	0.84	0.73	1.00	0.68	0.84	0.77	0.66	0.79	0.83
	22	.60	.51	.62	.56	.63	.33	.48	.43	.48	.49	.54	.49	.93	.61
Monthly total		1.46	1.49	1.46	1.39	1.42	1.17	1.21	1.43	1.16	1.33	1.31	1.15	1.72	1.44
August	9	0.88	0.89	0.96	0.90	0.72	0.67	1.11	0.96	0.40	0.64	0.38	0.76	0.48	0.19
	11	0	0	0	0	0	0	0	.26	1.00	.64	.62	.28	.22	.19
	20	1.24	.77	.92	.68	.84	.64	.94	.81	.68	.74	.97	.70	1.03	.80
Monthly total		2.12	1.66	1.88	1.58	1.56	1.31	2.05	2.03	2.08	2.02	1.97	1.74	1.73	1.18
September	7	0.38	0.08	0	0.07	0.01	0.03	0.25	0.04	0.03	0.02	0.21	0.01	0	0
	10	.11	.53	.30	1.11	.74	.64	1.73	1.10	1.48	.76	.60	.73	1.00	.37
	16	.29	.22	.21	.21	.28	.43.	.48	.90	.92	1.22	1.08	1.22	.70	1.76
	19	1.00	.92	.92	.92	.99	1.43	.1.05	1.28	1.28	1.50	1.40	2.02	1.49	2.10
	26	.03	.31	.50	0	0	.41	0	0	0	.18	0	.15	0	.22
	30	.10	.24	.34	.47	.33	.48	.32	.06	.09	.12	.07	.09	.08	.05
Monthly total		1.91	2.30	2.27	2.78	2.35	3.39	3.83	3.38	3.80	3.80	3.36	4.22	3.27	4.50
1958 Water year total		40.61	38.06	37.17	36.94	36.91	37.82	38.22	39.60	39.50	39.24	39.64	40.80	39.75	41.94
October	3	0.18	0.16	0.16	0.15	0.15	0.17	0.18	0.20	0.18	0.20	0.25	0.21	0.26	0.30
	21	1.09	.93	.86	1.10	.78	.47	.74	.52	.42	.57	.58	.86	.56	1.15
	29	.04	.05	.06	.05	.05	.05	.05	.05	.05	.05	.04	.05	.04	.04
Monthly total		1.31	1.14	1.08	1.30	0.98	0.69	0.97	0.77	0.65	0.82	0.87	1.12	0.86	1.49
November	14	1.75	1.54	2.00	1.80	1.60	1.40	1.60	1.60	1.59	1.50	1.52	1.13	1.54	1.34
	16	.15	.10	.20	.24	.14	.12	.15	.15	.15	.10	.10	.14	.15	.07
	17	.22	.12	.43	.30	.16	.13	.16	.17	.15	.13	.15	.28	.21	.12
	27	.70	.75	.74	.77	.88	.75	.75	.70	.64	.68	.67	.70	.70	.78
Monthly total		2.82	2.51	3.37	3.11	2.78	2.40	2.66	2.62	2.53	2.41	2.44	2.25	2.60	2.31
December	1	0.39	0.42	0.41	0.42	0.34	0.41	0.41	0.38	0.40	0.38	0.37	0.35	0.39	0.43
	15	.02	.01	.02	.01	0	.02	.02	.04	0	.02	0	0	0	0
	22	0	.01	0	0	.03	.03	.01	.01	.05	.04	.08	.05	.04	.06

29–31	.28	.29	.31	.24	.32	.27	.28	.28	.30	.28	.29	.30	.31	.32
Monthly total	0.69	0.73	0.74	0.67	0.69	0.73	0.72	0.71	0.75	0.72	0.74	0.70	0.74	0.81
1958 Calendar year total	33.34	31.13	31.30	30.42	29.46	29.55	31.55	31.74	31.67	31.16	31.61	32.33	31.24	33.65
1959														
January 14	0.09	0.15	0.14	0.13	0.10	0.09	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.06
20–21	.15	.16	.18	.21	.23	.14	.17	.16	.12	.11	.10	.05	.12	.10
Monthly total	0.24	0.31	0.32	0.34	0.33	0.23	0.22	0.21	0.17	0.17	0.15	0.10	0.17	0.16
February 3	0.47	0.50	0.49	0.47	0.41	0.47	0.44	0.42	0.32	0.41	0.42	0.37	0.36	0.39
13–14	.68	.77	.79	.81	.82	.88	.83	.84	.80	.77	.80	.67	.83	.78
19	.12	.09	.12	.16	.11	.10	.12	.13	.05	.09	.07	.05	.08	.14
Monthly total	1.27	1.36	1.40	1.44	1.34	1.45	1.39	1.39	1.17	1.27	1.29	1.09	1.27	1.31
March 4	0.26	0.33	0.31	0.34	0.30	0.43	0.23	0.18	0.30	0.20	0.22	0.25	0.29	0.25
10	.08	.22	.30	.86	.78	.63	.93	1.20	1.22	1.37	.80	1.05	1.02	.73
20–21	.13	.20	.15	.16	.11	.22	.09	.11	.12	.25	.22	.21	.16	.23
25	.24	.28	.28	.29	.30	.39	.29	.44	.39	.50	.54	.58	.61	.48
31	.81	1.20	1.14	1.04	.96	.91	.85	.79	.91	.95	.78	.95	.87	.80
Monthly total	1.52	2.23	2.18	2.69	2.45	2.58	2.39	2.72	2.94	3.27	2.56	3.04	2.95	2.49
April 10	0.10	0.14	0.15	0.17	0.11	0.11	0.06	0.20	0.15	0.14	0.14	0.11	0.17	0.15
17	.37	.47	.45	.46	.51	.71	.64	.62	.51	.55	.60	.50	.79	.62
20	.08	.09	.07	.07	.07	.10	0	.14	.10	.11	.13	.17	.12	.20
Monthly total	0.55	0.70	0.67	0.70	0.69	0.92	0.70	0.96	0.76	0.80	0.87	0.78	1.08	0.97
May 5	0.32	0.37	0.34	0.32	0.32	0.44	0.29	0.30	0.40	0.49	0.37	0.37	0.47	0.47
8–9	.34	.39	.37	.34	.34	.46	.31	.27	.35	.41	.46	.46	.48	.48
10–11	1.09	1.24	1.17	1.09	1.09	1.45	1.00	1.16	1.50	1.82	1.77	1.76	1.45	1.45
22	.11	.18	.14	.16	.10	.10	.10	.12	.06	.07	.13	.14	.14	.12
23–24	.32	.52	.40	.45	.28	.29	.45	.52	.28	.32	.37	.37	.59	.44
Monthly total	2.18	2.70	2.42	2.36	2.13	2.74	2.15	2.37	2.59	3.11	3.10	3.13	2.96	2.50
June 1	0	0	0	0	0	0	0	0	0	0	0.12	0.02	0.87	0.14
2	.87	.82	.88	.80	.90	.76	.89	.68	.90	.83	.70	.70	.50	.64
4	1.01	.94	1.02	.93	1.04	.88	1.03	1.02	1.34	.60	1.07	.50	1.10	.32
7	.23	.21	.23	.20	.23	.20	.22	.32	.42	.43	.24	.34	.10	.36
12	.62	.39	.22	.23	.34	.50	.21	.56	.51	.50	.69	.70	.70	.77
22	.40	.53	.55	.61	.53	.45	.45	.38	.30	.30	.24	.31	.32	.22
22–23	3.52	3.70	3.56	3.57	3.38	3.75	3.07	2.82	2.91	3.00	3.10	2.13	2.80	2.00
25	.36	.39	.36	.36	.34	.42	.46	.40	.42	.54	.57	.84	.50	.76
26	.40	.44	.41	.42	.38	.44	.32	.29	.30	.32	.38	.34	.45	.33
Monthly total	7.41	7.42	7.23	7.12	7.14	7.40	6.65	6.47	7.10	6.52	7.11	5.88	7.34	5.54

TABLE 2.—*Summary of rainfall, in inches, for Honey Creek basin, June 1953 to September 1959*—Continued

[Recording gages (R) installed May 29, 1953. Standard gages (S) installed June 25, 1953]

Date of storm		Gage No.													
		1S	2S	3S	4S	5R	6S	7S	8S	9R	10S	11S	12R	13R	14S
	1959														
July	2	2.32	1.90	2.45	1.69	1.46	1.17	1.70	0.89	1.59	0.48	0.88	0.32	0.40	0.35
	6	.34	.32	.56	.21	.19	.18	.25	.51	.20	0	0	0	.05	.07
	15	.14	.24	.12	.11	.10	.10	0	0	0	.08	.26	.10	.30	.10
	16	2.14	2.68	2.04	1.98	1.91	1.85	1.02	.96	1.10	1.26	.21	1.20	.23	1.14
	17	.12	.12	.11	.10	.06	.06	0	0	0	0	.05	0	.05	0
	18–19	.39	.54	.37	.34	.26	.24	.30	.17	.54	.64	.64	.60	.79	.54
	20	.10	.12	.10	.10	.06	.06	.02	.01	.10	.16	.26	.13	.29	.12
	24	.17	.16	.20	.23	.18	.24	.43	.80	.50	.48	1.85	1.00	2.02	1.44
	26	1.08	1.01	1.15	1.20	1.08	1.29	1.00	1.10	.90	.88	.60	.91	.91	1.00
	27	.11	.07	.13	0	.15	0	0	0	0	0	0	0	.21	0
Monthly total		6.91	7.16	7.23	5.96	5.43	5.17	4.72	4.44	4.93	3.98	4.75	4.26	5.25	4.76
August	1	0	0	0	0	0	0	0	0	0	0.18	0.06	0.15	0	0.09
	15	0	0	0	0	0	0	0	0	0	.05	.10	.55	0	.74
	26	.74	.71	.70	.70	.78	.64	.82	.52	.60	.47	.40	.58	.26	.81
	27	.16	.15	.15	.15	.16	.12	.16	.11	.12	.73	.22	.89	.13	1.03
	30–31	1.05	1.02	1.01	1.01	1.10	.92	1.15	.98	1.10	1.01	1.32	1.23	1.07	1.48
Monthly total		1.95	1.88	1.86	1.86	2.04	1.68	2.13	1.61	1.82	2.44	2.10	3.40	1.46	4.15
September	25	0.01	0.02	0.01	0.02	0	0.05	0.04	0.05	0.10	0.09	0.01	0.10	0	0.07
	28	.83	.75	.73	.74	.80	.82	.81	.77	.80	.84	.81	.88	.73	.73
Monthly total		0.84	0.77	0.74	0.76	0.80	0.87	0.85	0.82	0.90	0.93	0.82	0.98	0.73	0.80
1959 Water year total		27.69	28.91	29.24	28.31	26.80	26.86	25.55	25.09	26.31	26.44	26.80	26.73	27.41	27.29

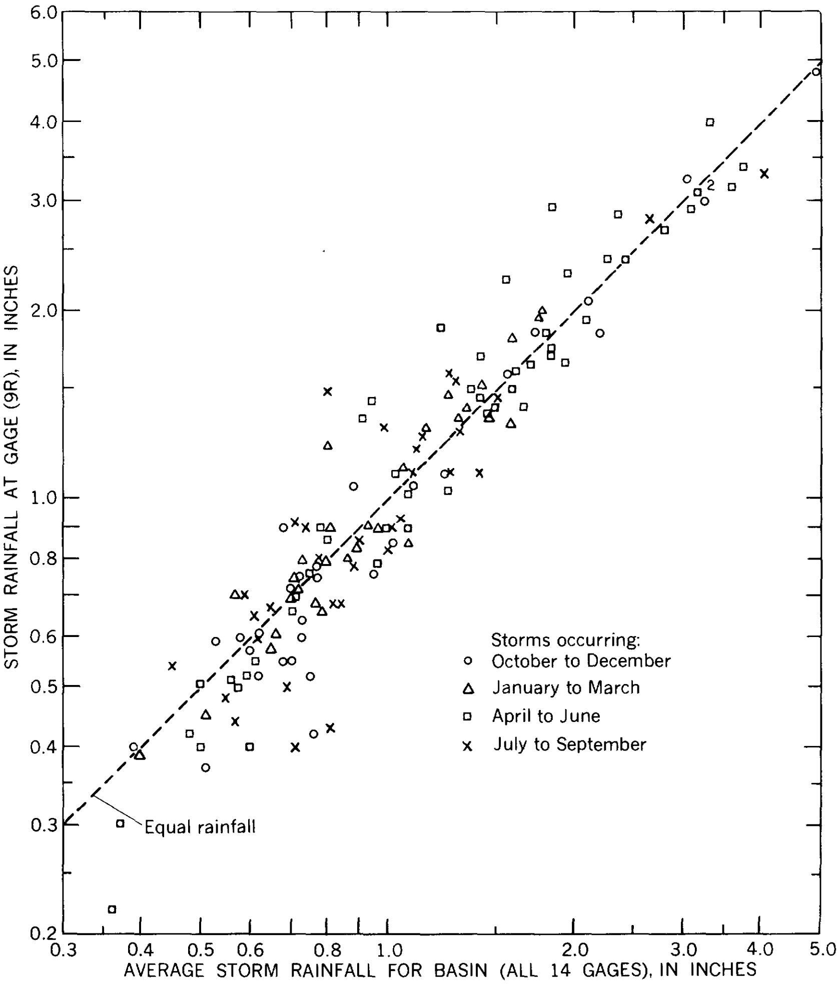

FIGURE 5.—Comparison of concurrent storm rainfall, 1 gage (9R) and 14 gages.

Similar results for the comparisons made involving the other gage combinations are 13 percent, 12 percent, and 8 percent, respectively. These graphical comparisons are shown in figures 6, 7, and 8.

Most hydraulic or hydrologic analyses are not concerned with average storm rainfall of less than 1 inch. Had this criterion been followed here, many of the points that deviated widely from the mean would have been eliminated. The results of the comparison using average precipitation for four gages as the ordinate (8 percent) are considered excellent for a series of concurrent occurrences in nature. Although these results indicate that for this area the areal distribution of storm rainfall is fairly uniform and that perhaps the use of only

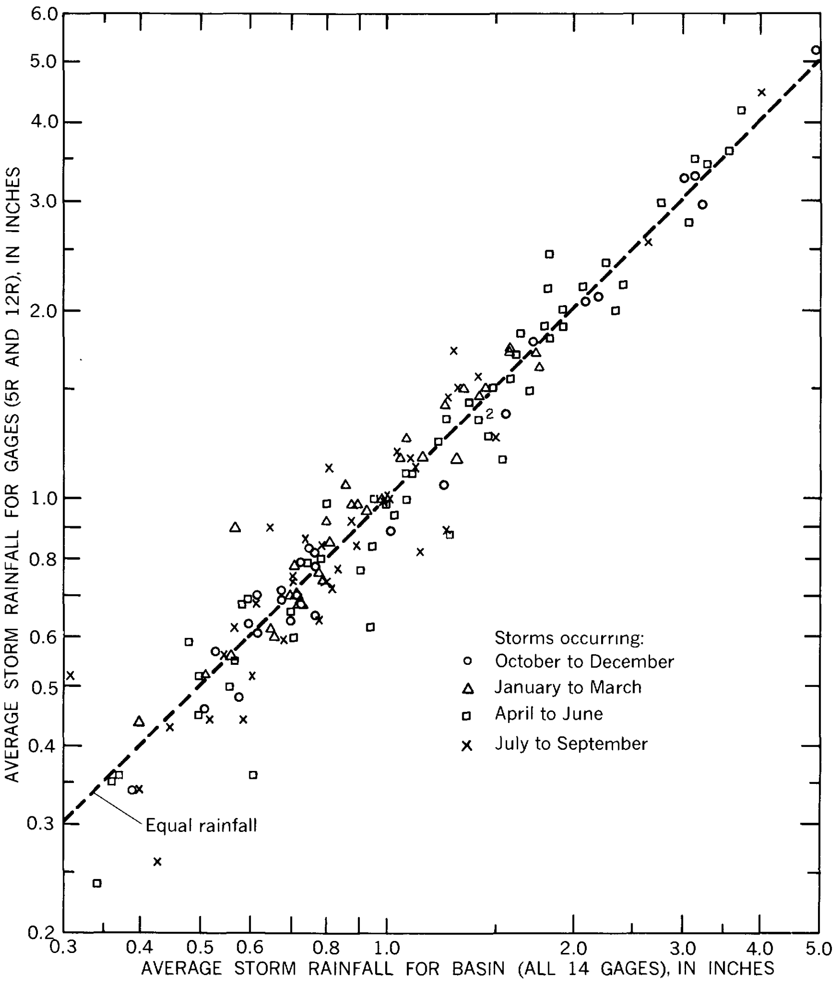

FIGURE 6.—Comparison of concurrent storm rainfall, 2 gages (5R and 12R) and 14 gages.

four rain gages would give satisfactory basin rainfall coverage, the other gages are necessary for hydrologic studies in the watersheds controlled by structures. It should be pointed out that these graphical comparisons are biased to some extent by the method used in distributing the weekly yield of the nonrecording rain gages. Since the amount of storm rainfall allotted to the nonrecording gage is based on the distribution of weekly storm rainfall at the nearest recording gage, the procedure would give more weight to the rainfall at the recording gage. This bias is not considered serious in these comparisons.

MAGNITUDE AND FREQUENCY

As an indication of the rainfall experienced during 1954–59 relative to the long-term rainfall experience, a comparison was made on a calendar year basis with past rainfall records collected at McKinney by the U.S. Weather Bureau since 1903. The table below gives this comparison:

Station and period	Average annual rainfall (inches)	Number of storms during period with 24-hour rainfall total, in inches, of—				
		3–4	4–5	5–6	6–8	>8
McKinney, 1903–53	39.24	21	12	5	1	0
Honey Creek study basin:						
1954	34.37	2	0	0	0	0
1955	23.90	0	0	0	0	0
1956	22.34	1	0	0	0	0
1957	60.11	4	1	0	0	0
1958	31.44	0	0	0	0	0
1959	31.43	0	0	0	0	0

The figures in the table are for the calendar years. This table shows that no unusually large storm occurred during the period of this study, and that an insufficient number of large storms occurred to make the 6-year record a representative sample.

The U.S. Weather Bureau has compiled long term rainfall intensity, duration, and frequency curves for a number of their recording stations in Texas. The data are published in U.S. Weather Bureau Technical Paper No. 25. The nearest Weather Bureau recording station to the Honey Creek basin is that at Dallas, 33 miles south. The graph shown for Dallas in that technical publication is reproduced and shown as figure 9. As is pointed out in Technical Paper No. 25, the curves as shown on the graph are computed from the annual series (maximum value for each year). For many rainfall analyses the annual series data are not as useful as the partial-duration series data. The partial-duration series data include several of the highest events occurring in any one year and by doing so recognizes that the magnitude—for instance—of the third-highest event occurring in some years may exceed the highest of another year. To make the data adaptable to the partial-duration series, the Weather Bureau developed empirical factors by which the curve values shown in figure 9 for the annual series can be multiplied to obtain the relative partial-duration series values. These factors are presented herein:

2-year return period	1.13
5-year return period	1.04
10-year return period	1.01
Longer periods	1.00

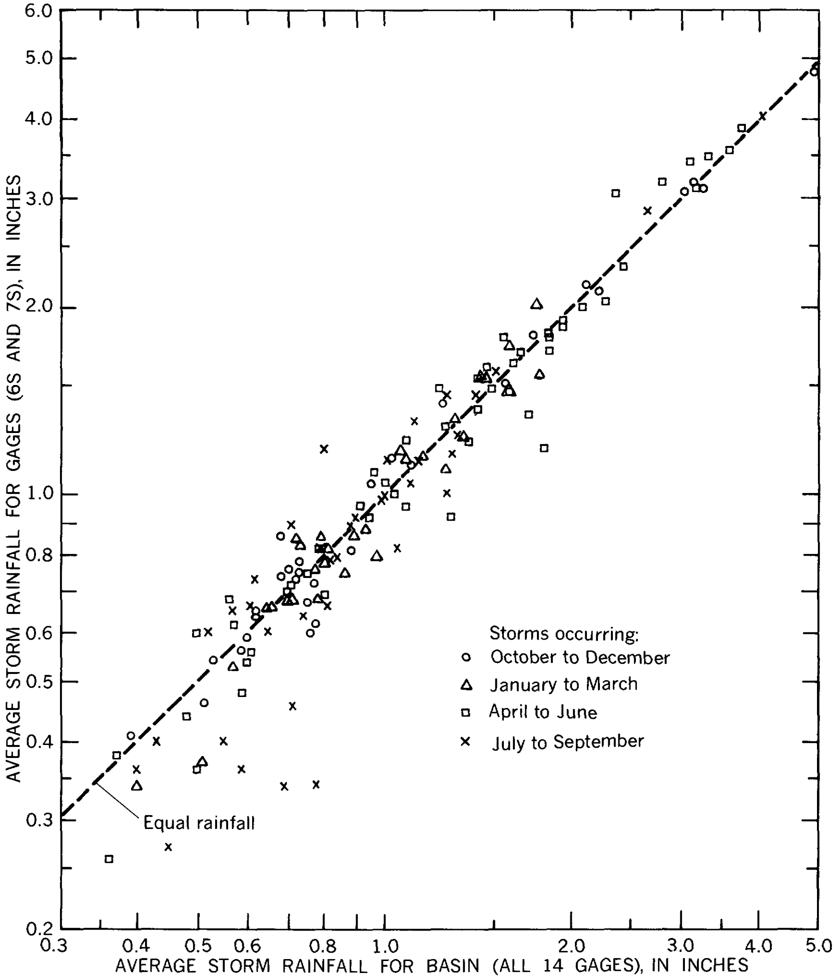

FIGURE 7.—Comparison of concurrent storm rainfall, 2 gages (6S and 7S) and 14 gages.

The curves were based on data for the period 1914–51. The average annual rainfall at Dallas for the period 1903–59 is 34.34 inches, which is 4.43 inches below the 1903–59 average annual rainfall at McKinney, Tex.

Curves showing the maximum expected depth and frequency of occurrence of rainfall for time periods of 15, 30, and 60 minutes are given in figure 10. The curve values were computed by taking the curve values of figure 9, converting them from the annual to the partial-duration series values, and changing them from intensity to depths for the specified time periods shown. These curves can be

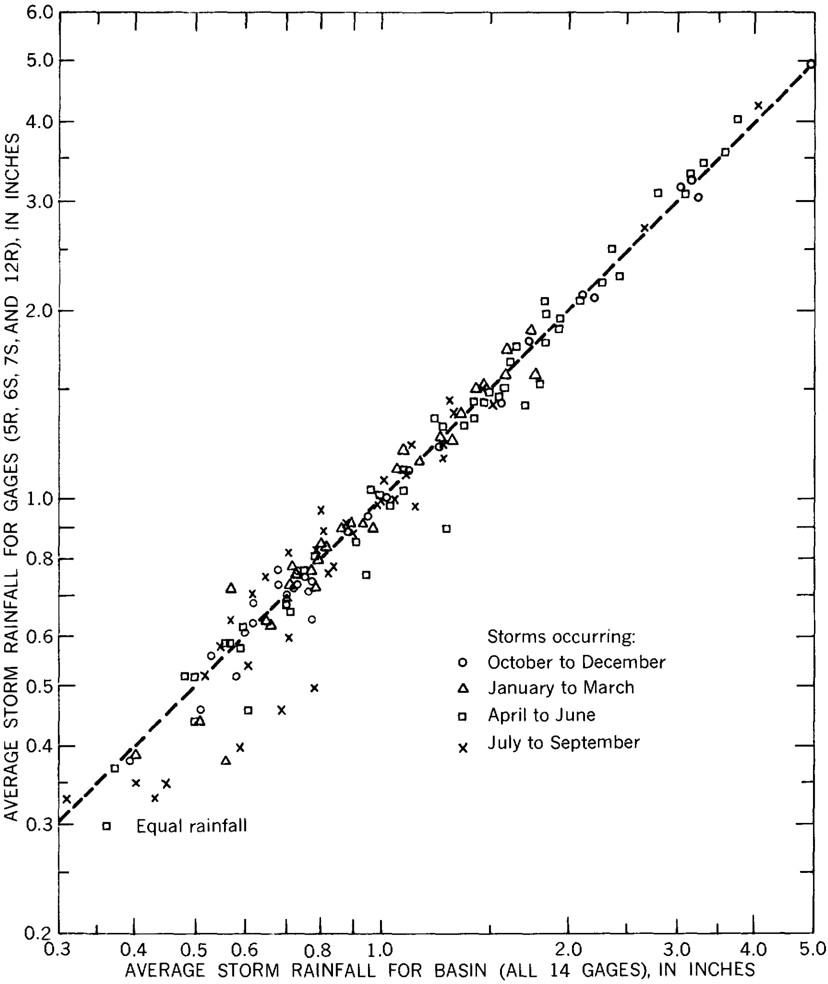

FIGURE 8.—Comparison of concurrent storm rainfall, 4 gages (5R, 6S, 7S, and 12R) and 14 gages.

used to determine the frequencies of the rainfall increments experienced at sites 11 and 12 that are shown in tables 3 and 4. For example, the maximum 60-minute increment of rainfall shown in these tables (that for the storm of May 21, 1957, at site 12) has a recurrence interval of 4 years. The maximum 30- and 15-minute increments shown have recurrence intervals of 5 and 7 years, respectively. Thus the earlier stated conclusion that no unusually large storm has occurred is strengthened by this additional appraisal.

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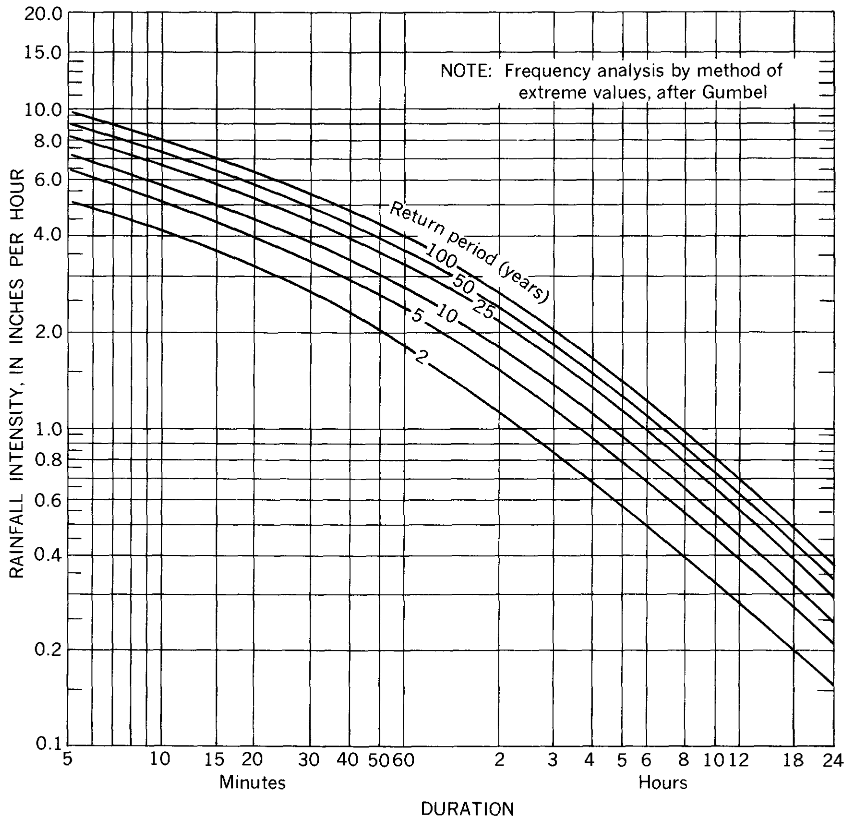

FIGURE 9.—Rainfall intensity, duration, and frequency curves for Dallas, Tex. (From U.S. Weather Bur. Tech. Paper 25).

UPSTREAM RUNOFF

POOL GAGES AND PERIOD OF RECORD

At the end of the report period, 54 percent or 20.9 square miles of the 39.0-square-mile basin of study was controlled by a total of 12 floodwater-retarding structures. The first of these structures was completed in the summer of 1951; the last was completed in July 1957. Installation of pool-level gages was begun in September 1952, when continuous water-stage recorders were put in operation at sites 11 and 12. Beginning in late 1954, staff gages were installed at other existing structures and at each new one as it was completed. Instrumentation for the pool stations was completed in November 1957. Details are shown in table 1.

The recording gages are housed in metal shelters over metal stilling wells near the center of the dams. Intake pipes extend from the

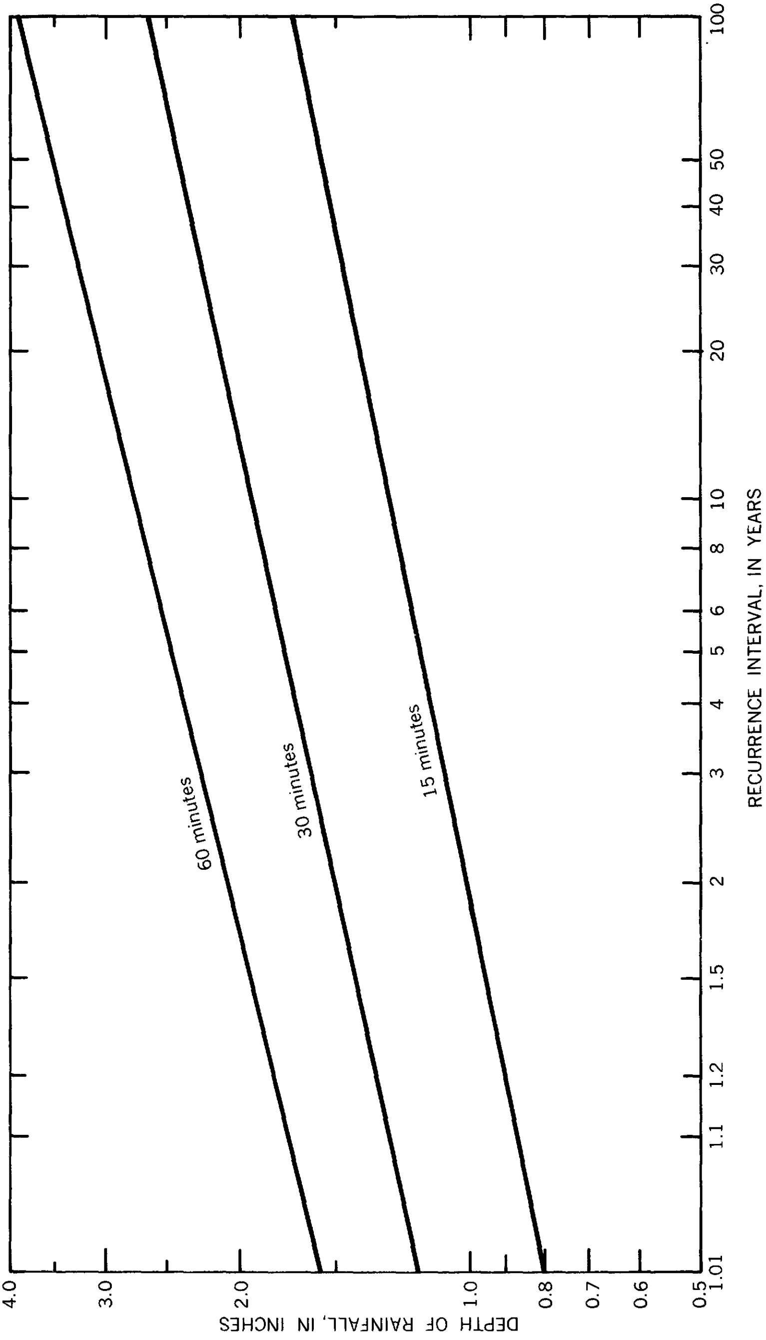

FIGURE 10.—Rainfall frequency curves for 15-, 30-, and 60-minute totals at Dallas, Tex.

stilling well into the sediment pool. The recorders operate with a chart speed of 9.6 inches per day to facilitate selection of small time increments in computing hydrographs. A gage-height scale of 1 inch=0.5 foot permits instantaneous observations to nearest hundredth of a foot.

Staff-gage installations consist of enameled gage plates attached to wood posts set vertically in the pool bank. Two sections of each gage plate (3.3 ft each) are attached to each post and the posts are staggered up the slope of the bank. Gages are read weekly to nearest hundredth of a foot.

Peak-stage indicators were installed on each staff-gage section in November 1959. These indicators furnish peak pool stages occurring between visits.

The location and designation of each pool-level gage is shown in figure 4.

Records of pool stage serve two major purposes. Stages are necessary to the computation of change in pool contents and subsequently to computation of pool inflow rates. They are also used to compute pool outflows over spillways or through conduits.

With a few exceptions the pool gages and records of stage have proved to be satisfactory for use in computing total inflow and outflow. For sites 11 and 12, no real problem with pool-level records has existed at any time. No intake lag of consequence was experienced during the report period. At the other ten sites, a record of a peak stage was not always obtained when stage exceeded the top of the uncontrolled outlet structure; however, this information is now obtained from observations of the peak-stage indicators previously mentioned.

With the aid of the recorded pool levels at sites 11 and 12, a daily stage graph was prepared for each of the other sites with weekly staff-gage record covering the period from the time the gage was established to Sept. 30, 1959. These stage graphs are considered adequate for this study.

INFLOW TO FLOODWATER-RETARDING POOLS

BASE INFLOW

Inflow to the floodwater-retarding pools is usually intermittent. Continuous inflow occurs during the winter months if preceded by moderate autumn rainfall. Staff gages read weekly are maintained on the principal stream discharging into the floodwater-retarding pools at sites 11 and 12. Discharge measurements were obtained at these gage sites at approximately 5-week intervals in addition to the weekly observer's notations of "flow" or "no flow." No inflow gages are maintained upstream from the other structures.

Curves showing the approximate stage-discharge relation were developed for the inflow gages at sites 11 and 12 and were used to compute inflow during base flow conditions. At the other ten sites the relatively small quantities of base flow were estimated on the basis of those found at sites 11 and 12 and on the change in pool contents. For future hydrologic investigations in this area, it is intended that base inflow shall be measured at all sites.

TOTAL INFLOW

It is recognized that the most economical procedure of gaging the runoff from small watersheds with floodwater-retarding structures is by the method of gaging the change in pool contents in a unit of time. In this procedure the basic equation used is

$$Q_i = Q_o \pm \Delta S + C$$

Q_i=the inflow and includes the rainfall on the pool surface.
Q_o=the outflow through designed outlet works.
ΔS=the indicated change in pool contents.
C=the pool consumption which includes losses by evaporation, seepage, and transpiration. It is recognized, however, that the seepage is not a loss when it contributes to ground water.

If a unit of time is introduced in the basic equation given above, all the terms become rates. The equation gives accurate results in the computation of total volume of inflow, but the accuracy of rates of inflow depends on factors which have not been totally isolated. However, computed rates are presented since a definite need for them exists.

The instrumentation at sites 11 and 12, yielding a continuous record of pool stage, is sufficient for the determination of reasonably accurate inflow rates using the equation given above. The daily stage graphs prepared from the weekly readings of staff gages at the other sites permitted only the computation of average daily rates of inflow.

The determination of the terms Q_o and C of the basic equation are discussed in later sections of the report. The determination of the term ΔS is discussed here. When the 3 terms on the right side of the equation are known, the term Q_i can be computed.

The area-capacity tables for each pool were furnished in skeleton form by the Soil Conservation Service. These tables were expanded by the Geological Survey for use in determining pool contents for each hundredth of a foot change in gage height. The tables used are indicative of the original pool contents and no adjustments were made for reduction in storage due to sedimentation during the period covered by this report. Adjustments were not made because changes in incremental storage due to sedimentation depend solely upon changes in surface area. Sedimentation in the upper portions of the reservoirs was small; therefore, adjustments would have been negligible and were not considered necessary.

After stages were determined from the stage graphs, prepared as discussed previously, contents and changes in storage were determined. A minimum time interval of one day was used for sites with staff gages only. The recorded gage heights at sites 11 and 12 permitted the use of minimum time intervals of 15 minutes in determining the inflow hydrographs.

The indicated change in contents includes the effect of rainfall on the pool surface in each computation of inflow. In most major storms the time of concentration of the peak rate of inflow is such that most rainfall has ceased at the time of the peak. However, in the case of recurring storm rainfall it was necessary to deduct the rain that fell on the pool during the time interval used in computing the peak rate of inflow. Monthly change in contents at all sites is given in table 14.

ANALYSES OF INFLOW

Because defining the storm hydrology of small watersheds is one major purpose for the pool stations, many analyses were made of the inflow rates and volumes experienced at sites 11 and 12 during periods of storm runoff. The individual concurrent storm data used in these analyses are shown in tables 3 and 4. The values shown in these tables for rainfall represent the weighted rainfall in the case of "Depth" and point rainfall at the nearest recording gage in the case of "Maximum increment." It will be noted that the storm date and volume may conflict with values shown in table 2. This is due to the fact that some of these storms were not broken down into the specific periods of rainfall causing specific amounts of runoff, which is necessary in any rainfall and runoff analysis. The values for runoff shown in tables 3 and 4 have been adjusted by subtracting that rainfall occurring on the pool surface during inflow. Only the maximum runoff rate occurring during the water year is shown and this rate represents the average rate of inflow over a 15-minute time interval. The values shown for infiltration are the residuals of rainfall after extraction of runoff.

Attempts to correlate storm rainfall with the resulting runoff for sites 11 and 12 were not successful, even when rainfall intensity and antecedent rainfall were used.

It was seen in the graphical comparisons involving basin rainfall shown in figures 5, 6, 7, and 8 that the computed storm rainfall for the individual sites can be expected to be uniformly distributed. Some hydrologists give credence to the theory that variability of

TABLE 3.—*Storm rainfall and runoff data for site 11, water years 1953–59*

[Drainage area, 2.14 sq mi]

Date of storm	Rainfall					Runoff		Infiltration (inches)
	Duration (hours)	Depth (inches)	Maximum increment			Depth (inches)	Max. rate (cfs)	
			15 min. (inches)	30 min. (inches)	60 min. (inches)			
1953								
Sept. 3	9.5	1.58	0.76	0.98	1.19	0.068		1.51
Oct. 23	5.0	1.07	.14	.21	.38	.021		1.05
25	7.0	1.07	.24	.41	.51	.028		1.04
Nov. 3–4	23.0	1.28	.12	.18	.20	.026		1.25
7	6.0	.89	.20	.30	.52	.017		.87
19	2.6	1.10	.37	.47	.70	.031		1.07
1954								
Apr. 11–12	10.7	2.58	.52	.84	.90	.115		2.46
30	3.0	2.09	.90	1.12	1.64	.183		1.91
May 10	12.0	1.64	.46	.78	.87	.049		1.59
11–12	24.0	2.14	.11	.21	.33	.573		1.57
27	.8	.84	.46	.71		.026		.81
June 8	1.6	1.41	.82	.93	.95	.122	235	1.29
15	4.4	1.98	.68	1.11	1.30	.136		1.84
July 14	7.0	1.30	.40	.40	.42	0		1.30
31	2.0	1.23	.53	.72	.75	0		1.23
Aug. 23	.6	1.23	.81	1.15		.047		1.18
Sept. 30	19.7	2.86	.60	.87	1.15	.203		2.66
Oct. 23	20.0	2.03	.15	.21	.33	.105		1.92
1955								
Feb. 3–4	16.0	1.29	.17	.31	.41	.070		1.22
19	6.4	1.45	.30	.40	.50	.191	42	1.26
Mar. 20	4.0	1.09	.64	.80	.92	.122		.97
Apr. 9	23.0	.89	.17	.29	.42	.043		.85
May 18–19	11.0	1.34	.14	.22	.34	.115		1.22
June 18	4.5	1.22	.34	.45	.59	.005		1.22
Sept. 26	2.2	1.65	1.19	1.60	1.60	.061		1.59
30	4.0	1.47	.42	.70	1.04	.054		1.42
1956								
Feb. 15–16	2.2	1.48	.67	.83	1.04	.179		1.30
17	5.3	1.90	.67	.77	.80	.605		1.30
Apr. 29–30	12.0	1.59	.46	.66	.87	.028		1.56
May 1	11.0	1.70	.39	.51	.60	.240	256	1.46
Nov. 3–4	33.0	2.62	.22	.30	.49	.054		2.57
Dec. 18–19	35.0	1.94	.13	.20	.32	.019		1.92
1957								
Mar. 17	3.0	1.17	.29	.43	.60	.045		1.12
31	8.7	1.76	.63	.83	.90	.660		1.10
Apr. 19	3.5	3.20	.45	.69	1.27	1.16		2.04
20–21	4.0	1.21	.59	.78	.90	.720		.49
23	8.5	1.92	.42	.65	.70	1.25		.67
24	2.7	1.28	.66	.69	.87	1.04		.24
25–26	23.0	3.03	.51	.55	.60	2.48		.55
May 3	6.4	.94	.44	.51	.55	.650		.29
12	2.3	1.22	.59	.87	1.12	.430		.79
13	3.7	1.78	.70	.90	1.02	1.31		.47
18	5.0	.73	.52	.54	.58	.430		.30
21	1.4	2.83	.89	1.30	1.83	1.96	1,630	.87
22	1.0	.73	.38	.60	.73	.680		.05
23	6.0	1.60	.38	.73	.96	1.50		.10
25	13.5	3.23	.75	.95	1.07	2.72		.51
26	2.8	1.74	.61	.82	1.17	1.55		.19
Sept. 21–22	19.0	2.15	.24	.31	.38	.017		2.11
Oct. 13	9.0	1.68	.56	.68	.72	0		1.68
Nov. 3–5	54.0	4.93	.20	.23	.40	.511		4.42
7	10.0	.79	.25	.36	.40	.255		.54
24	8.0	.71	.07	.14	.17	.209		.50
Dec. 24–25	14.5	1.17	.14	.20	.23	.165		1.10
1958								
Jan. 12	20.0	1.18	.30	.34	.36	.240		.94
Mar. 28–29	3.2	.97	.37	.40	.50	.181		.79
Apr. 8	2.3	.83	.20	.30	.57	.083		.75
13	9.3	.76	.07	.10	.14	.089		.67
25–26	25.0	1.61	.33	.60	.68	.243		1.37
28	10.6	.85	.55	.69	.69	.290		.56
29	7.5	1.12	.54	.62	.84	.880		.24
30	12.5	2.40	.72	1.10	1.27	1.91		.49

TABLE 3.—*Storm rainfall and runoff data for site 11, water years 1953–59*—Con.

Date of storm	Rainfall					Runoff		Infiltration (inches)
	Duration (hours)	Depth (inches)	Maximum increment			Depth (inches)	Max. rate (cfs)	
			15 min. (inches)	30 min. (inches)	60 min. (inches)			
1958								
May 1	1.2	1.97	1.06	1.60	1.85	1.58	1,880	0.39
2–3	14.0	1.08	.26	.33	.45	.930		.15
Aug. 20	3.5	1.01	.52	.67	.72	.005		1.00
Sept. 16	2.5	.79	.37	.47	.60	.007		.78
19	13.0	1.47	.26	.30	.35	0		1.47
Nov. 14	4.5	1.53	.50	.85	.87	.003		1.53
1959								
Mar. 10	1.4	.97	.42	.74	.93	.002		.97
31	2.8	.85	.63	.66	.68	0		.85
May 10–11	8.2	1.52	.54	.72	.80	.009		1.51
June 4	2.0	1.10	.64	.85	1.06	.017		1.08
22–23	23.0	2.86	.41	.54	.85	.073		2.79
July 24	1.2	1.98	.87	1.70	1.92	.063	156	1.92
26	11.0	.84	.07	.14	.23	.028		.81
Aug. 30–31	4.0	1.13	.58	.67	.73	.005		1.12

TABLE 4.—*Storm rainfall and runoff data for site 12, water years 1953–59*

[Drainage area, 1.26 sq mi]

Date of storm	Rainfall					Runoff		Infiltration (inches)
	Duration (hours)	Depth (inches)	Maximum increment			Depth (inches)	Max. rate (cfs)	
			15 min. (inches)	30 min. (inches)	60 min. (inches)			
1953								
Sept. 3	9.3	1.47	0.61	0.75	0.92	0.021		1.45
Oct. 23	5.2	1.01	.14	.20	.37	.007		1.00
25	6.8	1.01	.23	.40	.51	.037		.97
Nov. 3–4	20.3	1.36	.09	.14	.20	.017		1.34
7	6.0	.73	.13	.22	.28	.006		.72
19	3.0	1.00	.33	.55	.70	.021		.98
1954								
Apr. 11–12	10.7	2.37	.54	.84	.90	.180		2.19
30	3.0	2.15	.54	1.00	1.62	.250		1.90
May 10	13.0	1.61	.38	.61	.71	.035		1.58
11–12	20.0	2.06	.18	.24	.45	.840		1.22
27	1.1	.71	.40	.58	.68	.089		.62
June 8	1.7	1.46	.76	.78	.80	.255		1.20
15	4.3	1.95	.52	.98	1.21	.306	212	1.64
July 14	11.5	.93	.37	.48	.54	.017		.91
31	10.0	.63	.17	.20	.23	0		.63
Aug. 23	2.4	1.88	.90	1.38	1.64	.091		1.79
Sept. 30	14.0	3.53	.96	1.34	1.90	.472		3.06
Oct. 23	22.0	2.47	.19	.29	.50	.520	123	1.95
1955								
Feb. 3–4	16.0	1.58	.30	.41	.53	.180		1.40
19	6.3	1.26	.32	.42	.49	.260		1.00
Mar. 20	5.8	.95	.50	.60	.77	.142		.81
Apr. 9	23.0	.95	.15	.26	.43	.068		.88
May 18–19	11.0	1.29	.10	.15	.23	.080		1.21
June 18	5.0	1.26	.40	.49	.60	.041		1.22
Sept. 26	2.0	.54	.40	.42	.44	.001		.54
30	4.6	.79	.25	.45	.66	.006		.78
1956								
Feb. 15–16	2.5	1.54	.58	.83	1.16	.230		1.31
17	5.0	1.83	.62	.74	.80	.885	295	.94
Apr. 29–30	12.0	1.67	.50	.72	.95	.094		1.58
May 1	11.2	1.92	.56	.65	.72	.531		1.39
Nov. 3–4	33.0	2.59	.29	.33	.42	.059		2.53
Dec. 18–19	34.0	1.93	.15	.20	.35	.032		1.90

TABLE 4.—*Storm rainfall and runoff data for site 12, water years 1953–59*—Con.

[Drainage area, 1.26 sq mi]

Date of storm	Rainfall					Runoff		Infiltration (inches)
	Duration (hours)	Depth (inches)	Maximum increment			Depth (inches)	Max. rate (cfs)	
			15 min. (inches)	30 min. (inches)	60 min. (inches)			
1957								
Mar. 17	3.0	1.29	0.29	0.47	0.68	0.053	------------	1.24
31	8.5	1.25	.36	.38	.39	.257	------------	.99
Apr. 19	4.3	4.06	.63	1.14	1.90	2.27	------------	1.79
20–21	4.0	1.21	.42	.63	.72	.560	------------	.65
23	8.3	2.35	.48	.95	1.10	1.84	------------	.51
24	2.7	1.36	.60	.80	.92	1.23	------------	.13
25–26	24.0	3.42	.39	.77	.94	3.14	------------	.28
May 3	8.0	1.06	.54	.75	.77	.679	------------	.38
12	2.8	.81	.46	.62	.70	.390	------------	.42
13	3.8	1.31	.59	.70	.75	.980	------------	.33
18	5.0	.89	.64	.70	.73	.561	------------	.33
21	2.5	3.61	.90	1.40	2.40	3.00	1,490	.61
22	1.5	.70	.23	.40	.65	.560	------------	.14
23	5.7	1.71	.46	.70	.89	1.57	------------	.14
25	14.0	3.72	.92	1.08	1.16	3.67	------------	.05
26	3.7	2.27	.82	1.12	1.86	2.24	------------	.03
Sept. 21–22	18.6	2.37	.24	.42	.55	.020	------------	2.35
Oct. 13	10.2	1.77	.44	.54	.60	0	------------	1.77
Nov. 3–5	44.0	5.23	.19	.29	.48	1.30	------------	3.93
7	10.5	.80	.20	.31	.33	.207	------------	.59
24	8.0	.72	.08	.15	.18	.142	------------	.58
Dec. 24–25	14.2	1.16	.12	.15	.23	.118	------------	1.04
1958								
Jan. 12	20.0	1.06	.30	.30	.36	.121	------------	.94
Mar. 28–29	3.6	.85	.32	.38	.45	.121	------------	.73
Apr. 8	2.2	.77	.17	.28	.48	.077	------------	.69
13	9.4	.78	.06	.09	.13	.053	------------	.73
25–26	25.0	1.76	.38	.56	.60	.431	------------	1.33
28	4.0	.87	.58	.75	.85	.600	------------	.27
29	2.4	1.45	1.20	1.24	1.37	1.41	------------	.04
30	16.6	2.31	.48	.85	.95	2.10	------------	.21
May 1	1.2	1.73	.78	1.30	1.57	1.58	1,500	.15
2–3	14.8	.77	.20	.24	.34	.630	------------	.14
Aug. 20	2.9	.72	.38	.44	.48	.003	------------	.72
Sept. 16	1.2	1.31	.63	.84	1.18	0	------------	1.31
19	11.0	2.00	.22	.36	.58	.021	------------	1.98
Nov. 14	4.4	1.19	.40	.51	.60	.012	------------	1.18
1959								
Mar. 10	1.6	1.02	.42	.65	1.00	.021	------------	1.00
31	2.7	.93	.70	.79	.87	.018	------------	.91
May 10–11	15.0	1.71	.66	.74	.82	.044	------------	1.67
June 4	1.5	.48	.15	.26	.36	.009	------------	.47
22–23	23.0	2.16	.34	.42	.52	.030	------------	2.13
July 24	1.5	1.04	.50	.75	.84	.062	Unknown	.98
26	11.0	.92	.15	.23	.31	.024	------------	.90
Aug. 20–21	4.0	1.26	.66	.86	.89	.015	------------	1.24

rainfall over a watershed is the major reason for the lack of correlation between storm rainfall and resulting runoff. While this factor of variable rainfall is undoubtedly significant for a large watershed, it does not appear to be significant in this case. The poor correlation between storm rainfall and the resulting runoff which was attained can then be attributed to the many variable factors that influence the route of a raindrop after it has fallen on the land surface.

A least-squares regression of the concurrent individual storm runoffs at sites 11 and 12 is shown in figure 11. Although the standard error of estimate for this regression is rather poor, +73 percent and

716–823 O—64——6

—42 percent, the results are much better than those obtained by relating rainfall and runoff. The results are more reliable for runoffs in excess of 0.5 inch.

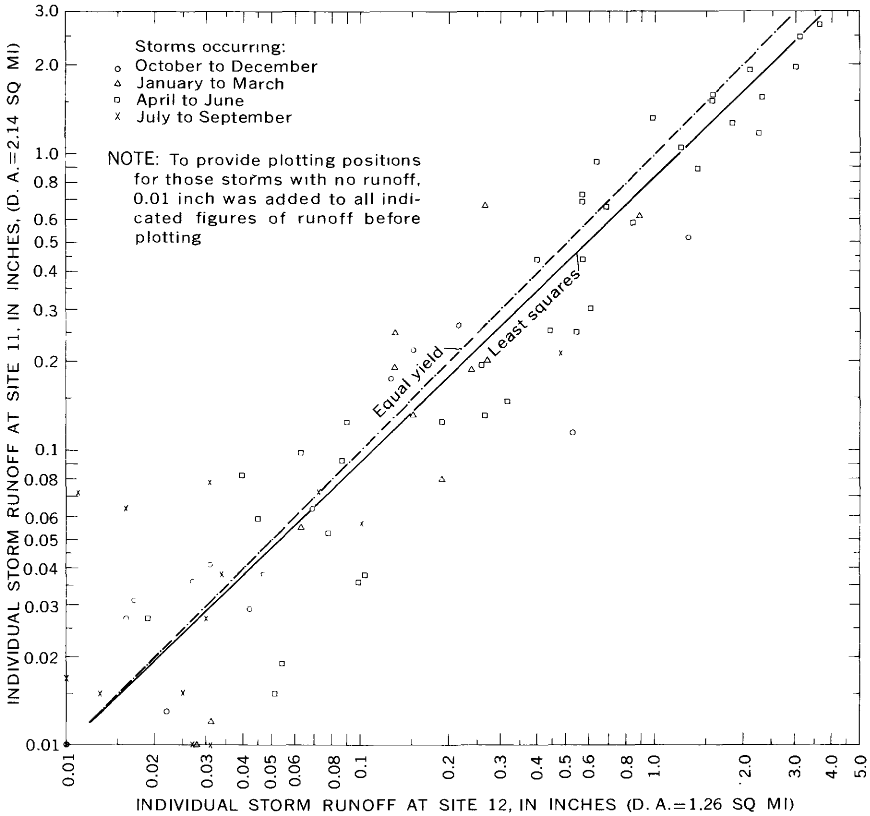

FIGURE 11.—Regression of individual concurrent storm runoff at sites 11 and 12.

A summation of the storm rainfall amounts shown for the 76 storms in each of the tables 3 and 4 gives a difference of only 0.05 inch at the two sites out of a total of 118.59 inches at site 12. A similar summation of runoff amounts shows that the total runoff depth at site 11 was only 79 percent of that at site 12. This compares favorably with the figure of 83 percent obtainable from the equation for the regression line shown in figure 11. The following table showing land-treatment measures in the two watersheds offers some clue as to the reason for the difference in apparent depth yield at the two sites—for example, the difference in depression storage afforded by the practices shown for terracing and pond construction. Land-treatment measures shown are as of December 31, 1956, and are considered average for the watershed during the period covered by this report.

Practice	Site 11	Site 12
Cover cropping .... acres..	220	200
Contour farming .... do....	202	120
Rotation hay and pasture .... do....	835	75
Crop residue utilization .... do....	180	500
Proper use .... do....	500	30
Rotation grazing .... do....	600	200
Pasture planting .... do....	379	110
Brush control .... do....	5	4
Wildlife area improvement .... do....	42	44
Terracing .... miles..	18. 3	6
Diversion construction .... do....	. 8	--------
Waterway development .... number..	4	3
Waterway development .... acres..	8	4
Pond construction .... number..	8	2
Total drainage area .... acres..	1, 368	809

It is reasonable to assume that the soils are alike and the total concurrent storm rainfalls average about the same on the two watersheds. The differences in yield might be attributed to differences in antecedent conditions of soil moisture, differences in rainfall intensities, or to differences in natural depression storage. Differences in soil moisture should be negligible immediately following periods of direct runoff, and therefore the effect of soil moisture differences can be eliminated by selection of storms which occurred closely following periods of direct runoff. The 14 storms listed in the table on page 38 conform to this condition.

For these storms correlations of runoff with rainfall amounts and rainfall intensities failed to indicate any effect by intensity. Difference in yield of the two watersheds may be related to differences in basin storage, but no conclusive evidence is available.

Study of the data from the table on the next page on maximum 15-minute rainfall and runoff rates indicates that the average reduction of rainfall rate to the runoff rate was 79 percent at site 11 and 63 percent at site 12. The average reductions of the total storm rainfall to total runoff were 29 percent and 20 percent respectively.

Inflow hydrographs prepared for these sites do not indicate that all of this rate reduction can be attributed to channel storage or tributary lag. These data are interpreted to mean that, although soil moisture is a causative factor for variation in runoff from a given amount of rainfall, the dominant factor causing the variation between watersheds could well be natural depression storage. There may be times when soil moisture can safely be used as an index to runoff; however, antecedent storm rainfall might satisfy soil moisture requirements but fail to contribute to depression storage. Data for many more storms of this type are needed in order to further isolate important variables. It is suspected that on small watersheds such as these, the peak rate of runoff is influenced by intense rainfall occurring in time intervals of less than 15 minutes.

Selected storms closely following periods of direct runoff

[Maximum 15-minute rate of rainfall obtained from gage 13R for site 11 and from gage 12R for site 12]

Date of storm	Maximum 15-minute rates (inches per hour)		Ratio of runoff to rainfall	Total for storm (inches)		Ratio of runoff to rainfall
	Rainfall	Runoff		Rainfall [1]	Runoff	
Site 11 (drainage area, 2.14 sq mi)						
1957						
Apr. 19	1.80	0.38	0.21	3.20	1.16	0.36
20-21	2.36	.35	.15	1.21	.66	.55
23	1.68	.27	.16	1.92	1.25	.65
24	2.64	.33	.12	1.28	1.04	.81
25	2.04	.20	.10	.56	.42	.75
May 3	1.76	.36	.20	.94	.65	.69
21	3.56	1.19	.33	2.83	1.96	.69
22	1.52	.33	.22	.73	.68	.93
23	1.52	.69	.45	1.60	1.50	.94
25	3.00	.77	.26	3.23	2.72	.84
1958						
Apr. 28	2.20	.16	.07	.85	.29	.34
29	2.16	.36	.17	1.12	.88	.79
30	2.88	.51	.18	2.40	1.91	.80
May 1	4.24	1.37	.32	1.97	1.58	.80
Site 12 (drainage area, 1.26 sq mi)						
1957						
Apr. 19	2.52	0.98	0.39	4.06	2.27	0.56
20-21	1.68	.30	.18	1.21	.56	.46
23	1.92	.66	.34	2.35	1.84	.78
24	2.40	.63	.26	1.36	1.23	.90
25	1.04	.32	.31	.53	.41	.77
May 3	2.16	.54	.25	1.06	.68	.64
21	3.60	1.75	.49	3.61	3.00	.83
22	.92	.39	.42	.70	.56	.80
23	1.84	1.03	.56	1.71	1.57	.92
25	3.68	1.35	.37	3.72	3.67	.99
1958						
Apr. 28	2.32	.62	.27	.87	.60	.69
29	4.80	1.43	.30	1.45	1.41	.97
30	1.92	.90	.47	2.31	2.10	.91
May 1	3.12	1.76	.56	1.73	1.58	.91

[1] Weighted.

Graphical illustrations of storm rainfall and runoff distribution were prepared for most major storms occurring during the period of this report at sites 11 and 12. For the sake of brevity, only those for period April 28 to May 3, 1958, are presented. Plates 1 and 2 are hydrographic plots showing rates of inflow and outflow in cubic feet per second, and the interval accumulation of rainfall and runoff in inches. Inflow includes rainfall on the pool surface, and the accumulated rainfall is the weighted value for the watershed.

RAINFALL ON POOL SURFACE

Table 14 shows values for the monthly rainfall at the gage nearest the pool (col. 5) and the total volume of this rainfall on the pool surface area (col. 7). The rainfall on the pool was computed for each storm and summarized for each month. Therefore, a computation for rainfall on the pool using the figures shown in table 14 for rainfall and for average surface area would not necessarily give the same results as shown in column 7. The average pool surface area is given in this table as merely an indication of contents during the month.

The computations involved for detailed storm analyses at sites 11 and 12 (see pls. 1 and 2) were made without deducting rainfall on the pool surface, which introduced a maximum error of about 10 percent in the rate of inflow. Although this error is close to the expected range of error in computations of this type, adjustments have been made for rainfall for all published figures of peak rates of inflow. If a study of the inflow hydrographs were made for the purpose of design alone, the inclusion of rainfall on the pool would perhaps be proper since the design storm could easily give as much as 90 percent runoff from the area inundated by the pool.

The annual rainfall on the pool surface varied between 7 percent of the indicated inflow in 1957 and 1958 and 27 percent in 1959. The data collected during the period of study indicates that when annual runoff is less than 3 inches, the rainfall on the pool will comprise about 20 percent of the indicated inflow. Since investigations of this type necessarily deal with small quantities, consideration of rainfall on the pool surface appears to be essential in any overall quantitative analysis.

OUTFLOW FROM FLOODWATER-RETARDING POOLS

Outflow from the floodwater-retarding pools may occur in three ways: through the uncontrolled drop inlets, through the valved pipes, and over the sodded spillways. Pool-stage records define the head on each of these outlets at any time.

Detailed stage-discharge rating curves were derived for the uncontrolled outlets (drop-inlet type) at sites 11 and 12. These ratings were based on current-meter measurements of the outflow at various heads on the control structure. The hydraulic characteristics of this type of an outlet afford relatively easy rating as long as the outlets remain free of drift and debris. Only minor trouble was experienced from this source during the period of study.

Stage-discharge ratings for the uncontrolled outlets at the other ten sites were estimated on the basis of observed change-in-contents of the pools during periods of little or no inflow, defined ratings at other sites and known hydraulic parameters affecting flow. Since all ratings for this type outlet are similar, fairly good results were obtained. These estimated ratings have been checked by discharge measurements since the end of the period covered by this report.

The ratings for sites 11 and 12 should be accurate within 5–10 percent while those for the other 10 sites should be within 15 percent.

Each of the floodwater-retarding structures is equipped with a gated valve that permits draining part of the sediment pool. During the period covered by this report, the valves at many of the structures were opened on several occasions. Valve ratings were obtained at sites 11 and 12. These can be used, with accuracy, to determine the outflow at the other sites providing records of valve openings are available. Some landowners kept records of gate openings, and others did not. When time and amount of gate opening was not known, the plot of daily pool stages indicated when valve was open, and the change in pool contents afforded reliable estimates of the discharge. These drains can discharge a maximum of only about 4 cfs and thus do not materially affect the overall pattern of outflow during years of high runoff; however, this outflow does represent a gap in the surface-water budget of the watershed and should be considered. Furthermore, knowledge of the amount of water released through these drains would afford an excellent opportunity to collect information for evaluating channel losses below the structures.

Only one current-meter measurement of the flow over the sodded emergency spillways was obtained during the report period. This measurement was obtained at site 12. A discharge of 49 cfs over this 150-foot spillway was measured at a head of 0.9 foot.

Flow over the emergency spillways of all completed structures took place during the period April 25 to May 30, 1957. The flow was estimated on the basis of the one discharge measurement, theoretical spillway ratings, change in pool contents, and the flow past the downstream stream-gaging station. Flow over the sodded emergency spillways during the period April 25 to May 30 was as follows:

Site	(May 26, 1957) Maximum head (feet)	Days with flow	Total spillway discharge (acre-feet)
8C	1. 9	14	820
8F	2. 6	8	400
8G	2. 2	20	2, 130
8H	1. 6	10	850
9	3. 5	4	285
10	2. 2	7	290
11	1. 8	10	859
12	2. 2	10	498
13	2. 0	5	108
14	1. 3	4	69
Total			6, 310

Flow discharged over emergency spillways represents about 40 percent of the total structure discharge during this 35-day period.

The monthly and annual outflow from each structure is given in table 14.

BASIN OUTFLOW

A record of the surface outflow from the 39.0-square-mile basin of study is obtained from a stream-gaging station equipped with a continuous water-stage recorder located at the downstream end of the study area. The gage was established July 23, 1951. The streamflow gaged at this station represents the outflow from the upstream structures plus runoff from the uncontrolled part of the basin.

Pertinent information on the gaging station and records of daily discharge for the period July 1951 to September 1959 are as follows:

HONEY CREEK NEAR MCKINNEY, TEX.

Location.—Lat 33°17′, long 96°39′, on right bank at downstream side of highway bridge, 4.5 miles downstream from Haw Branch, 5.6 miles upstream from mouth, and 6.0 miles northwest of McKinney, Collin County.

Drainage area.—39.0 sq mi. (See table 1 for drainage area controlled by structures each year.)

Gage.—Water-stage recorder. Datum of gage is 563.68 ft above mean sea level, datum of 1929 (Soil Conservation Service reference mark).

Average discharge.—8 years (1952–59), 15.7 cfs (11,630 acre-ft per year).

Extremes.—Maximum and minimum discharge for the water years 1952–59 are contained in the following table:

Gage height and discharge at indicated time

Water year	Maximum			Minimum	
	Date	Discharge (cfs)	Gage height (feet)	Date	Discharge (cfs)
1952	Apr. 22, 1952	2,310	16.65	At times	No flow.
1953	May 15, 1953	2,340	16.65	do	Do.
1954	May 12, 1954	1,940	16.66	do	Do.
1955	Feb. 19, 1955	1,720	15.74	do	Do.
1956	May 1, 1956	1,410	14.27	do	Do.
1957	May 26, 1957	7,920	20.29	do	Do.
1958	May 2, 1958	4,580	18.70	do	Do.
1959	June 23, 1959	384	7.76	do	Do.

1952–59: Maximum discharge, 7,920 cfs May 26, 1957 (gage height, 20.29 ft); no flow at times each year.

Maximum stage known since at least 1930, 23.0 ft in spring of 1950, from information by local resident.

Remarks.—Records fair except those for periods of no gage-height record, which are poor. Bankfull stage in the vicinity of gage is about 15 ft (1,870 cfs). Minor diversions for irrigation above station in 1958 water year.

TABLE 5.—*Discharge of Honey Creek gaging station, in cubic feet per second, 1951–59*

1951

Day	July	Aug.	Sept.	Day	July	Aug.	Sept.	Day	July	Aug.	Sept.	Day	July	Aug.	Sept
1	------	0.5		9	------	0		17	------	0		25	[1] 1.1	0	
2	------	.5		10	------	0		18	------	0		26	1.0	0	
3	------	.4		11	------	0		19	------	0		27	.9	0	
4	------	.3		12	------	0		20	------	0		28	.8	0	
5	------	.3		13	------	0		21	------	0		29	.6	0	
6	------	.2		14	------	0		22	------	0		30	.6	[1] 0	
7	------	.1		15	------	0		23	[1] 0.3	1.3		31	.6	0	
8	------	.1		16	------	0		24	.6	.1	(1)				
Total													------	3.8	0
Mean													------	0.12	0
Runoff in acre-feet													------	7.5	0

[1] Discharge measurement or observation of no flow made on this day.

1951–52

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1		0.1	0	0.2	0.2	0	0.6	8.7	12	0.1		
2		.1	0	.1	.2	2.2	.2	9.7	10	0		
3		0	0	.2	.3	17	.2	8.5	8.3	.2		
4		0	0	.2	.2	1.6	.6	7.1	7.1	2.1		
5		0	.1	.2	.2	.3	.4	6.0	60	.2		
6		0	.1	.2	.1	.2	.2	5.2	15	0		
7		0	0	.2	.1	.2	.2	4.2	12	0	(1)	
8		0	.1	.1	.1	.2	.2	3.9	11	0		
9		0	0	0	.1	.3	.7	3.5	9.7	0		
10		0	0	0	.1	1.0	1.0	3.5	8.8	0		
11		0	0	0	6.1	.7	.5	2.6	7.9	0		
12		0	0	0	4.8	.3	[3] 150	2.7	6.7	0		(1)
13		0	0	0	.3	.2	[3] 40	2.4	5.7	0		
14		0	.1	0	.1	.2	2.3	2.0	4.7	0		
15		0	.1	0	.1	.2	1.3	1.4	3.9	0		
16		0	0	0	.1	.1	1.0	1.2	3.4	0		
17		0	[2] .1	0	.2	.2	.7	1.2	2.5	0		
18		0	.1	0	.1	2.5	.6	12	2.1	0		
19		[1] 0	.1	.1	.1	.4	.6	3.5	1.7	0		
20		0	.2	.4	.1	0	28	2.4	1.4	0		
21		0	.1	[1] .1	0	0	[3] 60	1.8	1.1	0		
22	(1)	0	.1	.1	.1	0	[3] 600	1.4	.9	0		
23		0	.1	0	.1	.2	[3] 600	198	.6	0		
24		0	.1	0	.1	[1] .1	18	[1] 34	.6	0		
25		0	.1	.1	[1] .2	.1	14	13	.5	0		
26		0	.1	.1	.3	.1	13	10	.3	0		
27		.2	.1	.1	.2	.2	12	23	.3	0		
28		.2	.1	.1	.2	.2	[1] 10	229	.2	0		
29		.1	.1	.1	.1	.4	9.7	36	.2	0		
30		0	.1	.1	-------	.6	9.0	18	.1	0		
31		-------	.2	.1	-------	1.0	---------	14	-------	[1] 0		
Total	0	0.7	2.2	2.8	14.9	30.7	1,575.0	669.9	198.7	2.6	0	0
Mean	0	0.02	0.07	0.09	0.51	0.99	52.5	21.6	6.6	0.84	0	0
Ac-ft	0	1.4	4.4	5.6	30	61	3,120	1,330	394	5.2	0	0

1951 Calendar year: Max --- Min -- Mean ---- Ac-ft ----
1951–52 water year: Max 600 Min 00 Mean 6.82 Ac-ft 4,950

[1] Discharge measurement or observation of no flow made on this day.
[2] Field estimate made on this day.
[3] No gage-height record; discharge estimated on basis of rainfall data and records for nearby stations.

TABLE 5.—*Discharge of Honey Creek gaging station, in cubic feet per second, 1951–59*—Continued

1952–53

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1		0	0	4.2	0.6	1.4	[1]3.4	23	8.1	0		
2		0	0	2.1	.6	1.7	2.5	19	6.9	0		
3		0	0	1.3	.7	1.5	2.1	18	6.4	[1]0		
4		0	0	1.2	.6	.7	1.9	18	4.2	0		
5		0	0	1.0	.7	.4	9.1	16	0	0		
6		0	0	.9	.7	.4	54	16	0	0		
7		0	0	.8	.5	.4	13	15	0	0		
8		0	0	.6	.5	.4	10	14	0	0		
9		0	0	.5	.5	11	6.7	14	0	0		
10		0	0	.5	1.5	19	4.3	29	0	0		
11		0	[1]0	.4	3.7	11	62	59	0	0		
12		0	0	[1].3	2.8	10	39	[1]181	0	0		
13		0	0	.4	1.9	7.7	11	[1]25	0	0		
14	(1)	0	0	.4	1.9	6.6	8.8	20	0	0	(1)	
15		0	0	.4	1.6	4.2	7.7	578	0	0		
16		0	0	.3	1.4	4.3	4.8	115	0	0		
17		0	0	.7	.7	5.5	4.8	46	0	0		
18		[1]0	0	1.3	.7	8.7	4.8	[2]32	0	0		
19		0	35	2.8	1.4	4.3	3.4	[2]27	0	0		
20		0	3.1	1.6	2.2	3.4	3.1	[2]24	0	0		
21		0	1.1	1.0	1.6	2.8	3.0	[2]19	0	1.1		
22		0	.9	.8	.9	2.3	2.4	17	0	0		(1)
23		0	.5	2.0	.8	2.4	133	16	0	0		
24		[1]0	.3	4.3	1.9	2.1	[1]80	15	0	0		
25		39	.2	2.5	1.8	1.7	11	14	0	0		
26		.9	.2	2.1	[1]1.0	1.8	6.2	13	0	0		
27		.1	.1	1.8	1.0	5.9	5.4	12	0	0		
28		0	.1	1.3	.9	2.7	430	11	0	0		
29		0	.1	1.1	-------	2.1	361	[1]10	0	0		
30		0	15	.9	-------	9.5	29	9.6	0	0		
31		-------	14	.9	-------	10	---------	9.0	-------	0		
Total	0	40.0	70.6	40.4	35.1	145.9	1,317.4	1,434.6	25.6	1.1	0	0
Mean	0	1.33	2.28	1.30	1.25	4.71	43.9	46.3	0.85	0.04	0	0
Ac-ft	0	79	140	80	70	289	2,610	2,850	51	2.2	0	0

1952 calendar year: Max 600 Min 0 Mean 7.12 Ac-ft 5,160
1952–53 water year: Max 578 Min 0 Mean 8.52 Ac-ft 6,170

[1] Discharge measurement or observation of no flow on this day.
[2] No gage-height record; discharge estimated on the basis of weather records and records for nearby stations.

TABLE 5.—*Discharge of Honey Creek gaging station, in cubic feet per second, 1951–59*—Continued

1953–54

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	0	0	0.1	0.1	3.4	0.2	0	[1]10	1.2		0	0
2	0	0	.1	.1	3.0	.2	0	27	9.2		0	0
3	0	[1]0	4.8	.1	2.5	.2	0	5.4	2.4		0	0
4	0	0	.7	.1	2.2	.1	0	3.2	1.2		0	0
5	0	.1	.2	.1	1.9	.2	0	2.6	1.2		0	0
6	0	.1	.1	.1	1.8	.3	0	1.8	1.1		0	0
7	0	4.5	.1	.1	1.5	.4	0	1.4	1.1		0	0
8	0	1.1	.1	.1	1.4	.3	0	1.0	217		0	0
9	0	.2	.1	.2	1.7	.3	.1	1.0	[3]13		0	0
10	0	.1	[1].1	.2	1.5	.3	0	27	[3]7		0	0
11	0	.1	.1	.3	1.0	.2	111	[1]42	[3]6		0	0
12	0	.1	.2	[1].3	[1].7	[2].1	[1]99	630	[3]5		0	0
13	0	.1	.2	.2	.9	.1	18	47	[3]4		0	0
14	0	.1	.2	.3	1.2	0	59	26	[3]3		0	0
15	0	.1	.1	18	1.3	0	41	19	[3]212		0	0
16	0	.1	.1	13	1.1	0	3.5	11	[1]22		0	0
17	0	.1	.1	3.5	.8	0	1.7	8.7	10		0	0
18	0	.1	.1	2.7	.9	.1	1.0	6.9	4.8		0	0
19	0	43	.1	2.8	1.8	.7	.6	6.6	1.7		0	0
20	0	4.9	.1	14	1.4	.1	.4	4.7	1 .0		0	[1]0
21	0	.3	.1	3.8	.4	.1	.3	[1]4.0	.5		0	0
22	0	.2	.1	3.0	.3	.2	.3	3.2	.3		0	0
23	[1]0	.1	.1	2.0	.3	0	.2	2.2	.2	(1)	0	0
24	0	.1	.1	50	.3	0	.2	1.7	0		.3	0
25	19	.1	.1	32	.3	3.6	.2	33	0		0	0
26	30	.1	.1	16	.3	.6	.2	14	0		0	0
27	.1	.1	.1	7.1	.3	.2	.2	60	0		[1]0	0
28	0	.1	.1	5.7	.2	.2	1.0	10	0		0	0
29	0	.1	.1	4.8	—	.1	.2	5.5	0		0	0
30	0	.1	.1	5.9	-------	0	[1]184	4.3	—		0	50
31	0	-------	.1	4.0	-------	0	---------	2.0	-------		0	-------
Total	49.1	56.1	8.8	190.6	34.4	8.8	522.1	1,022.2	524.9	0	0.3	50
Mean	1.58	1.87	0.28	6.15	1.23	0.28	17.4	33.0	17.5	0	0.01	1.67
Ac-ft	97	111	17	378	68	17	1,040	2,030	1,040	0	0.6	99

1953 calendar year: Max 578 Min 0 Mean 8.53 Ac-ft 6,180
1953–54 water year: Max 630 Min 0 Mean 6.76 Ac-ft 4,900

[1] Discharge measurement or observation of no flow made on this day.
[2] Field estimate made on this day.
[3] No gage-height record; discharge estimated on basis of known peak stage.

TABLE 5.—*Discharge of Honey Creek gaging station, in cubic feet per second, 1951–59*—Continued

1954–55

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	[1]32	1.0	0.3	1.0	3.1	8.1	33	1.5	0.7	0.5		
2	.2	.8	.4	.8	2.3	9.6	23	1.1	.6	.4		
3	0	1.7	[1].3	.8	2.6	6.6	16	1.0	.5	.3		
4	0	2.6	.3	.8	52	[1]5.2	8.8	.8	.9	.3		
5	0	.5	.3	.8	17	5.0	5.5	.7	.6	.2		
6	0	.3	.2	.7	11	4.8	5.2	.7	.5	0		
7	.5	.2	.2	[1].6	10	4.8	4.3	.8	.3	0		
8	1.4	.2	.3	.6	8.1	3.6	[1]3.5	0	.2	0		
9	1.0	.2	.3	.8	6.9	3.4	11	0	.2	0		
10	.6	.2	.3	3.8	6.2	3.4	22	1.5	[1].2	0		
11	.4	.1	.4	1.7	2.7	2.8	11	2.2	.2	0		
12	.5	.1	8.9	1.2	4.2	2.5	17	1.3	.2	[1]0		
13	.4	.1	1.2	1.0	4.7	6.6	9.6	[1].8	.2	0		
14	.4	.2	.9	1.0	4.0	3.9	7.1	.5	.2	0		
15	.2	.3	.7	2.2	3.9	2.8	6.0	4.7	.2	0		
16	0	.4	.6	1.8	4.0	2.2	5.2	32	[1]8.1	0		(1)
17	0	.3	.5	1.5	2.5	2.0	5.0	14	1.0	0		
18	0	.2	.5	26	2.7	3.7	4.8	5.7	52	0		
19	0	.2	.4	6.9	339	12	3.9	49	4.2	0		
20	0	.2	.5	5.4	50	[1]71	3.6	50	3.0	0		
21	0	.2	.5	4.8	22	39	3.1	14	2.4	0		
22	0	.2	.5	4.2	18	18	2.7	7.1	2.1	0		
23	93	.2	.5	3.5	16	13	3.4	3.7	1.9	0		
24	6.6	.2	.5	3.5	11	10	2.3	2.7	1.5	0		
25	.1	.3	.6	3.0	8.7	9.7	1.9	1.8	1.2	0		
26	17	.3	.6	3.0	9.4	6.0	1.8	20	1.0	0		
27	[1]38	.3	.6	2.8	9.2	5.2	1.7	9.9	.9	0		
28	6.2	.3	1.2	[1]2.6	9.6	5.4	3.1	5.4	.8	0		
29	2.3	.3	2.4	2.2	-------	4.8	2.7	2.2	.7	0		
30	1.4	.2	1.2	2.4	-------	4.5	2.1	1.4	.6	0		
31	1.2	-------	1.0	2.6	-------	52	---------	1.0	-------	0		-------
Total	203.4	12.3	27.1	94.0	640.8	331.6	230.3	237.5	87.1	1.7	0	0
Mean	6.56	0.41	0.87	3.03	22.9	10.7	7.68	7.66	2.90	0.05	0	0
Ac-ft	403	24	54	186	1,270	658	457	471	173	3.4	0	0

1954 calendar year: Max 630 Min 0 Mean 7.11 Ac-ft 5,150
1954–55 water year: Max 339 Min 0 Mean 5.11 Ac-ft 3,700

[1] Discharge measurement or observation of no flow made on this day.

TABLE 5.—*Discharge of Honey Creek gaging station, in cubic feet per second, 1951–59*—Continued

1955–56

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1					0	0	0	272				
2					0	0	0	25				
3					0	0	0	8.3				
4		(1)			0	0	0	[1]2.7				
5					0	0	0	1.0				
6					0	0	0	.3			(1)	
7					0	0	0	.1				
8					0	.1	0	.1				
9			(1)		0	0	0	.1				
10					0	0	0	.1				
11					0	0	0	.1				
12					0	0	0	.1				
13					0	0	0	0				(1)
14	(1)				0	0	0	0				
15					.3	0	3.8	0				
16				(1)	110	0	.1	0				
17					217	0	.1	0				
18					16	0	0	0				
19					[1]4.8	0	0	0	(1)			
20					1.6	0	0	0				
21					.2	0	0	0				
22					.2	0	0	0				
23					.1	0	0	0			(1)	
24					.1	.1	0	0				
25					.1	.1	0	0				
26					.1	.1	0	0				
27					.1	[1].1	[1]0	0				
28					0	.1	0	0				
29					0	.1	0	0				
30					-------	0	20	0				
31		-------			-------	0	---------	0	-------			-------
Total	0	0	0	0	350.6	0.7	24.0	309.9	0	0	0	0
Mean	0	0	0	0	12.1	0.02	0.80	10 0	0	0	0	0
Ac-ft	0	0	0	0	695	1.4	48	615	0	0	0	0

1955 calendar year: Max 339 Min 0 Mean 4.45 Ac-ft 3,220
1955–56 water year: Max 272 Min 0 Mean 1.87 Ac-ft 1,360

[1] Discharge measurement or observation of no flow made on this day.

TABLE 5.—*Discharge of Honey Creek gaging station, in cubic feet per second, 1951–59*—Continued

1956–57

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1		0	0		0	0	146	180	129	11	0.3	0
2		0	0		0	11	[1] 35	[1] 180	126	11	.2	0
3		0	0		0	4.5	83	428	126	10	.1	0
4		14	0		0	.8	35	235	124	10	.1	0
5		14	0		0	.7	28	126	116	9.8	.1	[1] 0
6		.1	0		[1] 4.5	.6	21	120	105	9.8	.1	0
7		0	0		1.0	.5	11	111	98	9.6	0	0
8		0	0		0	.5	8.2	108	[1] 90	9.4	0	0
9		0	0		0	.4	7.0	128	83	9.4	0	0
10		0	0		0	.4	7.3	106	78	9.2	0	0
11		0	0		0	[1] .3	6.8	104	69	7.7	0	0
12		0	0		0	.3	5.9	207	66	7.3	0	0
13		0	0		0	.2	5.9	983	65	7.3	0	0
14		0	0		0	.1	5.4	144	60	6.4	0	0
15		0	0		0	0	5.0	119	47	5.9	0	0
16		0	0		0	0	3.6	167	43	[1] 5.7	0	0
17		0	[1] 0		0	37	2.9	112	40	5.4	0	0
18		0	0		0	5.0	2.0	332	40	5.2	[1] 0	0
19		0	0		0	2.0	[1] 1,080	114	36	5.4	0	0
20		0	.4		0	7.6	115	102	35	5.2	0	0
21		[1] 0	0		0	20	565	1,020	30	5.9	0	0
22		0	0		0	5.5	185	581	28	5.4	0	13
23		0	0		0	6.4	[1] 802	1,810	20	5.4	0	1.0
24		0	0		0	4.0	501	280	15	5.2	0	.1
25		0	0		0	2.9	151	[1] 3,040	12	5.4	0	0
26	(1)	0	0		0	2.0	[1] 1,850	1,910	11	4.9	0	0
27		0	0		0	21	449	164	11	2.6	0	0
28		0	0		0	19	143	141	10	1.6	0	0
29		0	0		—	[1] 9.0	183	132	11	1.0	0	0
30		0	0		------	22	238	129	11	.6	0	0
31		-------	0		------	103	---------	139	-------	.4	0	------
Total	0	28.1	0.4	0	5.5	286.7	6,681.0	13,452	1,735	199.1	0.9	14.1
Mean	0	0.94	0.01	0	0.20	9.25	223	434	57.8	6 42	0.03	0.47
Ac-ft	0	56	0.8	0	11	569	13,250	26,680	3,440	395	1.8	28

1956 calendar year: Max 272 Min 0 Mean 1.95 Ac-ft 1,420
1956–57 water year: Max 3,040 Min 0 Mean 61.4 Ac-ft 44,430

[1] Discharge measurement or observation of no flow made on this day.

NOTE.—No gage-height record Nov. 6, 7, Dec. 21, Feb. 6–8, Mar. 3–10, 12–14, July 30 to Aug. 7, Sept. 24, 25; discharge estimated on basis of weather records, field notes, and shape of previous recession curves.

TABLE 5.—*Discharge of Honey Creek gaging station, in cubic feet per second, 1951–59*—Continued

1957–58

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	0	0	16	12	20	7.8	26	[1] 616	9.6	0.6		0
2	0	0	16	12	19	8.6	23	[1] 1,240	9.6	.5	(1)	0
3	0	0	16	12	17	8.4	21	462	9.2	.4		0
4	0	16	14	11	22	9.8	18	226	8.8	.3		0
5	0	459	13	11	23	37	23	210	9.0	.6		0
6	0	112	26	11	23	39	16	205	9.6	1.1		0
7	0	185	26	11	16	59	12	175	9.4	.8		0
8	0	74	19	8.2	12	50	14	150	8.8	.6		0
9	0	40	14	9.0	14	37	31	110	8.6	.5		0
10	[1] 0	30	15	9.0	16	32	21	102	8.2	.5		0
11	0	30	13	9.6	[1] 15	28	17	100	[1] 7.7	.5		[1] 0
12	0	30	9.4	26	16	53	14	92	7.3	.4		0
13	0	30	10	49	12	48	18	[1] 94	7.0	.4		0
14	2.7	20	11	31	20	35	43	98	6.6	.3		0
15	.9	15	12	28	22	29	28	98	6.8	.3		0
16	.9	15	12	23	16	27	21	95	36	.3		0
17	.5	45	13	21	15	27	18	92	53	.2		0
18	.4	50	13	19	[1] 14	22	17	91	44	[2] .2		0
19	.4	25	12	29	14	20	17	82	39	.2		21
20	.3	20	8.6	88	13	19	27	72	24	.1		.2
21	.3	15	7.3	68	12	19	22	60	40	.1		.1
22	.3	15	7.5	45	13	19	18	50	49	.1		.1
23	.5	15	8.0	38	12	32	15	35	31	.1		0
24	.3	50	10	32	12	23	13	20	9.0	.1		0
25	.1	40	47	30	12	20	11	17	3.8	0		0
26	0	30	32	28	17	18	101	14	4.0	0		0
27	0	[1] 27	27	25	17	20	84	12	1.6	0		0
28	0	23	24	27	9.4	20	[1] 56	12	1.1	0		0
29	0	20	18	29	-------	87	930	11	.9	0		0
30	0	17	17	26	-------	42	1,050	11	.6	0		0
31	0	-------	18	25	-------	[1] 31	--------	10	-------	0		-------
Total	7.6	1,448	504.8	802.8	443.4	927.6	2,725	4,662	463.2	9.2	0	21.4
Mean	0.25	48.3	16.3	25.9	15.8	29.9	90.8	150	15.4	0.30	0	0.71
Ac-ft	15	2,870	1,000	1,590	879	1,840	5,400	9,250	919	18	0	42

1957 calendar year: Max 3,040 Min 0 Mean 66.7 Ac-ft 48,260
1957–58 water year: Max 1,240 Min 0 Mean 32.9 Ac-ft 23,820

[1] Discharge measurement or observation of no flow made on this day.
[2] Field estimate made on this day.

NOTE.—No gage-height record Oct. 18 to Nov. 3, Nov. 9–26, July 2–6, 8–17, July 19 to Aug. 1, Sept. 20–30; discharge estimated on basis of weather records, field notes, and shape of previous recession curves.

Hydrographs were plotted for most major storms occurring during the report period. The hydrograph for storms of April 28 to May 3, 1958 is shown in plate 3. During this period the maximum rate of flow passing the 12 upstream floodwater-retarding structures was about 150 cfs.

POOL EVAPORATION

EQUIPMENT AND PERIOD OF RECORD

Two types of equipment and two methods were used to collect information on pool evaporation. The first consisted of radiation and psychrometric equipment operated with a multi-channel potentiometer for recording the data necessary to compute evaporation by the energy-budget method. The energy-budget method is an accounting

TABLE 5.—*Discharge of Honey Creek gaging station, in cubic feet per second, 1951–59*—Continued

1958–59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1		0	1.4	1.8	0.5	0.6	35	0.1	0	0	0	
2		0	1.8	1.7	.6	.7	1.8	.1	.1	17	0	
3		0	1.9	1.2	[1] 1.4	.5	.8	.1	0	85	0	
4		0	1.3	.8	1.6	.7	.6	.1	19	34	0	
5		0	1.0	.6	1.4	1.1	.6	.1	1.4	30	0	
6		0	1.0	.7	.6	.7	.5	.1	.2	32	0	
7		0	1.0	1.1	.6	.5	.5	.1	.1	34	0	
8		0	1.0	1.3	.8	.6	.5	.1	0	32	0	
9		0	1.0	.9	1.1	[1].5	.4	.2	0	8.0	0	
10		0	1.0	.9	.8	1.4	.5	6.2	0	1.2	0	
11		0	1.0	1.0	.4	24	.5	6.5	0	.3	0	
12		0	1.0	1.1	.6	1.6	.5	.6	.2	.1	0	
13		0	1.0	1.1	.9	.9	.4	.2	0	.1	0	
14		0	1.0	1.1	6.3	.7	.3	.1	0	.1	0	
15	([1])	4.7	1.0	1.1	4.5	.3	.4	.1	[1] 0	0	0	([1])
16		.7	1.0	.8	1.7	.3	[1].5	.1	0	26	0	
17		.6	1.0	.8	1.3	.3	1.2	.1	0	46	0	
18		[2].3	1.0	.8	.7	.3	.8	.1	0	31	0	
19		[2].2	1.0	.9	.5	.3	.7	.1	0	23	0	
20		[2].1	1.0	1.0	.6	.5	.5	0	0	6.0	[1] 0	
21		[2].1	1.0	1.1	.6	.6	.4	[1] 0	0	1.3	0	
22		[2] 0	1.1	.7	.8	.4	.3	0	.4	.3	0	
23		[2] 0	1.2	.8	.8	.3	.3	.1	56	.1	0	
24		0	1.1	1.0	.8	.4	.3	.1	43	4.5	0	([1])
25		[1] 0	1.1	1.1	.8	.7	.2	.1	7.7	.1	0	
26		0	1.1	1.1	.8	1.4	.2	.1	17	6.6	0	
27		.2	1.1	.8	.7	.4	.2	0	24	3.3	0	
28		.8	1.1	.7	.7	.4	.2	0	3.5	[1].4	0	
29	([1])	1.4	[1] 1.1	.7	-------	.6	.2	0	.2	.2	0	
30		1.1	1.4	.5	-------	.6	.2	0	0	.1	0	
31		-------	1.7	.4	-------	.9	---------	0	-------	0	.1	-------
Total	0	10.2	35.4	29.6	32.9	43.2	49 5	15.5	172.8	422.7	0.1	0
Mean	0	0.34	1.14	0.95	1.18	1.39	1.65	0.50	5.76	13.6	0.003	0
Ac-ft	0	20	70	59	65	86	98	31	343	838	0.2	0

1958 calendar year: Max 1,240 Min 0 Mean 27.7 Ac-ft 20,030
1958–59 water year: Max 85 Min 0 Mean 2.22 Ac-ft 1,610

[1] Discharge measurement or observation of no flow made on this day.
[2] No gage-height record; discharge estimated on basis of weather records, observer's notes, and normal recession.

of all incoming and outgoing energy to a reservoir, the difference being that which is utilized for evaporation. Koberg (1958),[1] in the report on the Lake Mead studies, has described in detail how each term in the energy budget is evaluated.

In general, the energy-budget method of determining pool evaporation is considered to be the most accurate method presently available. However, owing to the expensive equipment required for its use, the energy-budget method was set up for a control period of only one year, Sept. 20, 1957, to Sept. 30, 1958. The primary use of the data collected during this control period was for the determination of certain coefficients necessary in the computation of evaporation by the less expensive mass-transfer method.

[1] Koberg, G. E., 1958, Energy-budget studies, *in* Water-loss investigations—Lake Mead studies: U.S. Geol. Survey Prof. Paper 298, p. 20–29.

Equipment needed for collecting data for the computation of evaporation by the mass-transfer method, the second of the two methods mentioned above, consisted of instruments for recording wind movement, water temperature, and air temperature and humidity. This equipment was in use Sept. 20, 1957, to Sept. 30, 1959 though not in the same form throughout the period. Part of the more expensive equipment used in the energy-budget study also was used in obtaining air temperature and humidity data for the mass-transfer study. After Sept. 30, 1958, a less expensive hygrothermograph was installed to obtain these data.

Figure 12 shows a raft anchored in the middle of the pool supporting an 8-day recording thermograph for measuring water-surface temperature and an anemometer with a totalizing dial for measuring wind movement. The totalizing dial was read weekly at the time the thermograph charts were changed.

Information on evaporation was collected at sites 11, 12, and 13. A raft was installed at each of these sites. As the three sites were not more than 2 miles apart, radiation and psychrometric instrumentation for the energy-budget study was set up near site 12 and used for the three sites. The hygrothermograph installed near site 12 also served three sites. An underwater thermometer was used to obtain temperature profiles at each of the three pools. The profiles were obtained at about 20 stations at each pool at approximately 5-week intervals during the 1958 water year at the ends of the energy-budget periods.

ENERGY-BUDGET RESULTS

The computation of evaporation by the energy-budget method in this study was limited to energy-budget periods between thermal surveys during the 1958 water year. Since each of these periods covered approximately 5 weeks and they were to be used only to define the coefficient in the mass-transfer equation, a monthly tabulation of the results was not made.

The annual evaporation by the energy-budget method for the 1958 water year was 48.8 inches for site 11, 51.9 inches for site 12, and 53.2 inches for site 13, a range of 4.4 inches.

The evaporation figures for site 13 are probably not as accurate as those for sites 11 and 12 because the computed values of inflow and outflow for site 13 were based only on weekly observations of pool stage. For sites 11 and 12, a continuous record of pool stage and a discharge rating for the drop-outlet were both available. The estimated maximum error of computed evaporation for sites 11 and 12 by the energy-budget method for periods of approximately a month is about 10 percent in summer and 13 percent in winter. On an annual basis the error should be less than 10 percent because the percentage

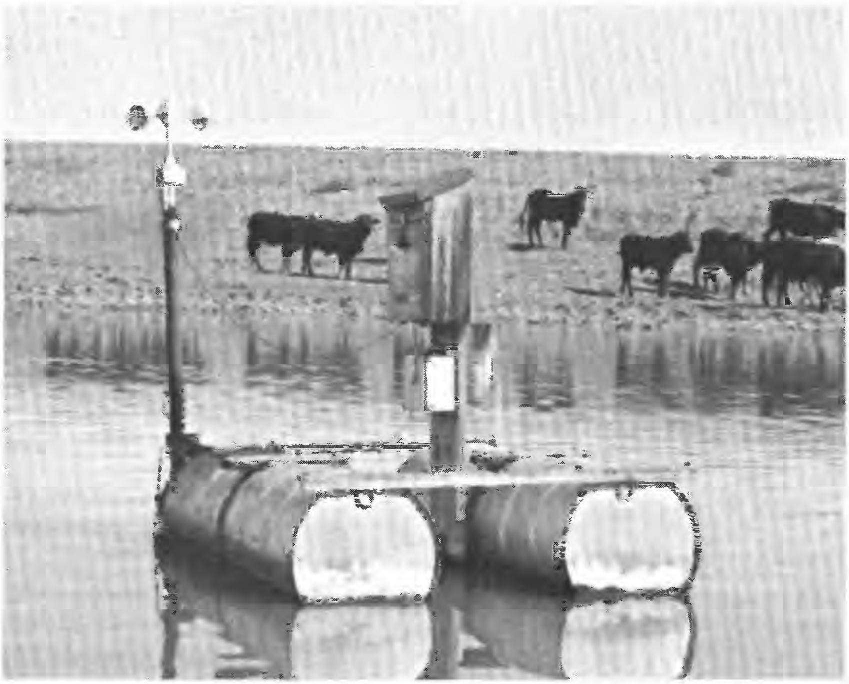

FIGURE 12.—Typical anemometer and thermograph installation on raft.

error in evaluating the change in energy storage decreases markedly as the length of period increases. During periods of low inflow and outflow, the figures of evaporation for site 13 are probably as accurate as those for sites 11 and 12.

The energy-budget computations indicated that some of the radiant energy that could have been utilized for evaporation the first year was taken out through the drop-outlet. However, for the second year, the three pools never spilled through their drop-outlets. Thus, some solar energy removed in outflow during the first year was not so lost the second year, and therefore was available for evaporation during the second year. The mass-transfer method takes into account this added energy through the rise in temperature of the water surface and for pools with this type of outlet probably gives more accurate results than does the energy-budget method.

DERIVATION OF MASS-TRANSFER COEFFICIENTS

Marciano and Harbeck (1954)[2] in the report on the Lake Hefner studies, discuss the mass-transfer theory and the many types of equa-

[2] Marciano, J. J., and Harbeck, G. E., 1954, Mass-transfer studies, *in* Water-loss investigations—Lake Hefner studies, Technical report: U.S. Geol. Survey Prof. Paper 269, p. 46-70.

tions that have been developed. The mass-transfer equation used for this study is expressed as follows:

$$E = N\,nu\,(e_o - e_a)$$

in which

E=total evaporation in depth units for period of n days.
u=Average wind speed for the period of n days.
n=number of days in period.
N=an empirical constant based on evaporation rates as determined by the energy-budget method.
e_o=saturation vapor pressure corresponding to the temperature of the water surface.
e_a=vapor pressure of the air.

The factors e_o and e_a were determined from average daily values of water-surface, air, and wet-bulb temperatures.

Whenever wind or water-surface temperature data were missing, they were estimated on basis of records obtained at adjoining sites. Missing air temperature, solar radiation and humidity data for energy-budget evaporation were estimated on the basis of Weather Bureau observations at Amon Carter Field, Fort Worth, Tex.

In order to obtain the coefficient N for use in the mass-transfer equation for evaporation, graphical plots of the energy-budget evaporation (ordinate) versus the product $nu(e_o - e_a)$ (abscissa) were made. The slope of the resulting curve of relation is the required coefficient N. These plots are shown for each site in figures 13, 14, and 15. The energy-budget evaporation is the total for the energy-budget period of usually about 5 weeks. The data for u and e_o were taken from the raft at each site and e_a taken at the radiation station. The resulting equation for site 11 is

$$E = 0.00293\,nu(e_o - e_a)$$

for site 12 is

$$E = 0.00313\,nu(e_o - e_a)$$

for site 13 is

$$E = 0.00402\,nu(e_o - e_a)$$

POOL EVAPORATION COMPUTED BY MASS-TRANSFER METHOD

Using the derived mass-transfer equation for each of the three sites, monthly evaporation rates and the corresponding volumes were computed for the period October 1957 to September 1959. The results are given in table 6. Also given in this table for comparative purposes is the pan evaporation obtained at the Denton Experiment Station some 30 miles directly west of the study area.

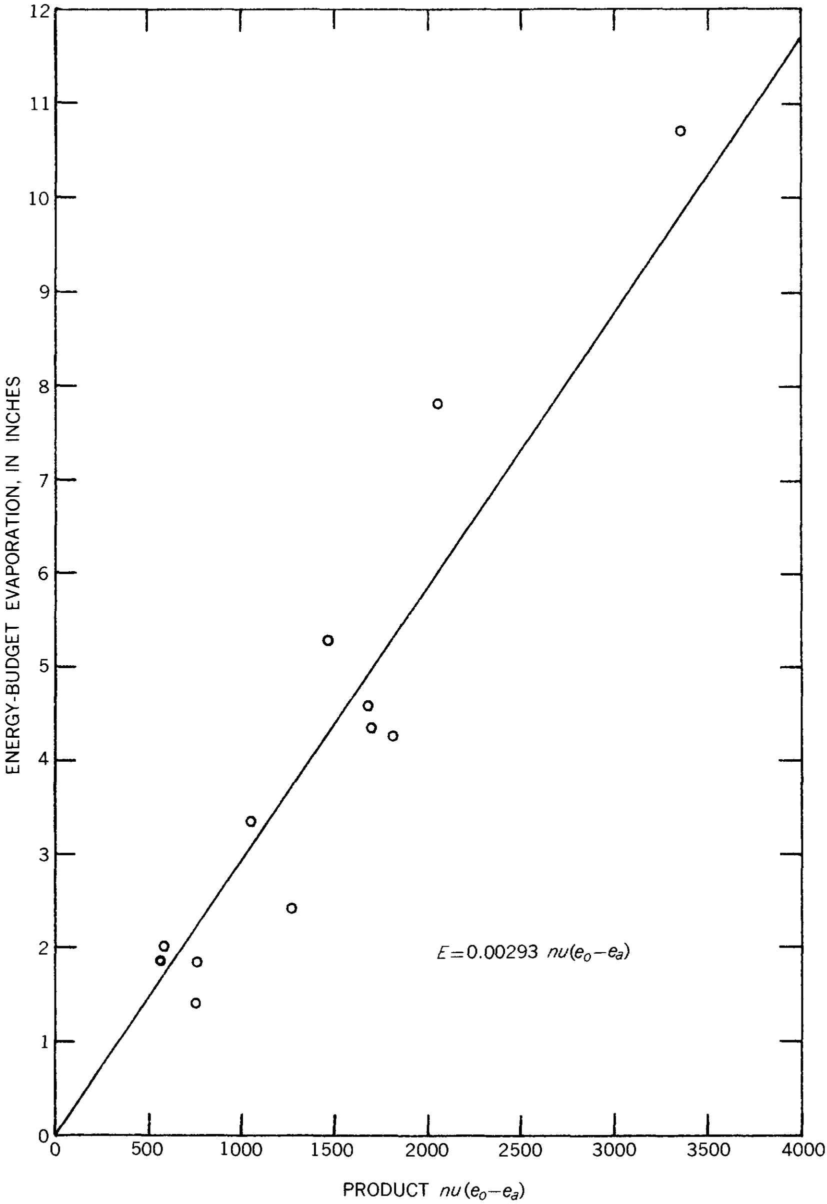

FIGURE 13.—Relation between energy-budget evaporation and the product $nu(e_o-e_a)$ for site 11.

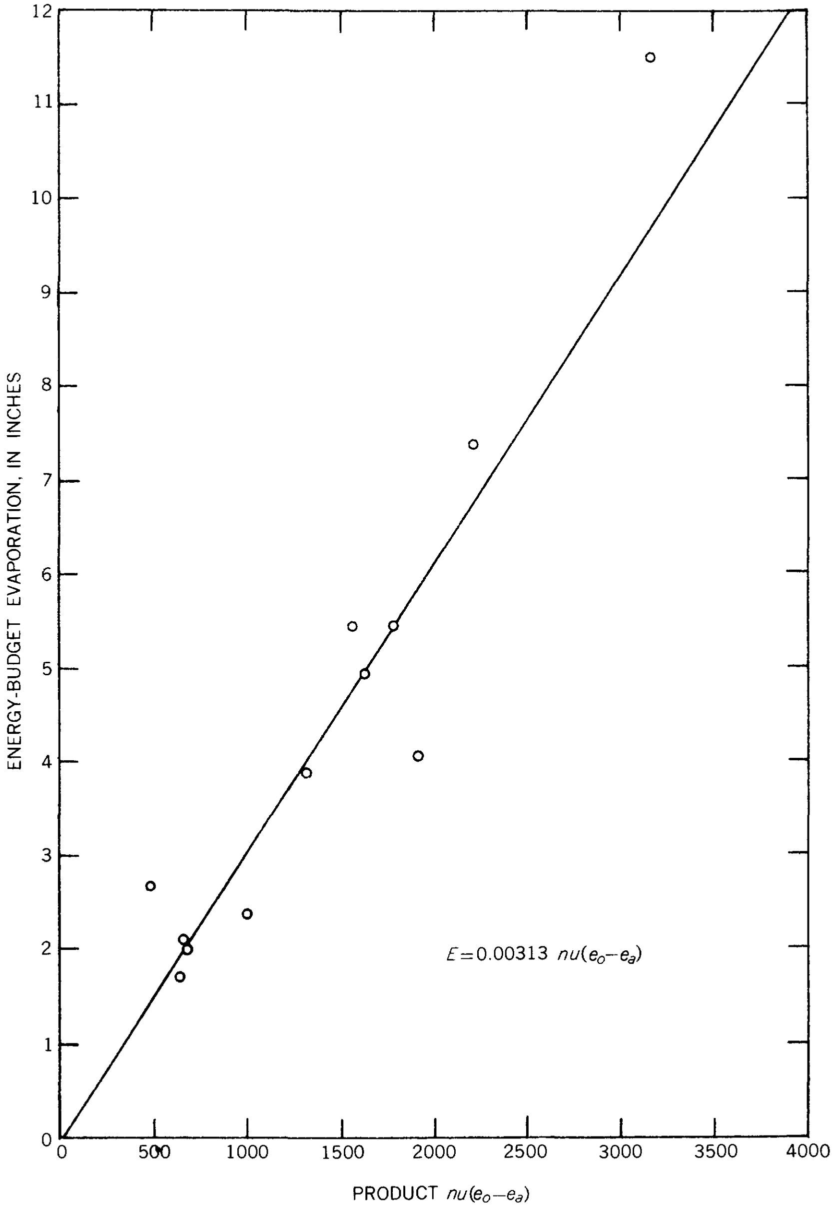

FIGURE 14.—Relation between energy-budget evaporation and the product $nu(e_o-e_a)$ for site 12.

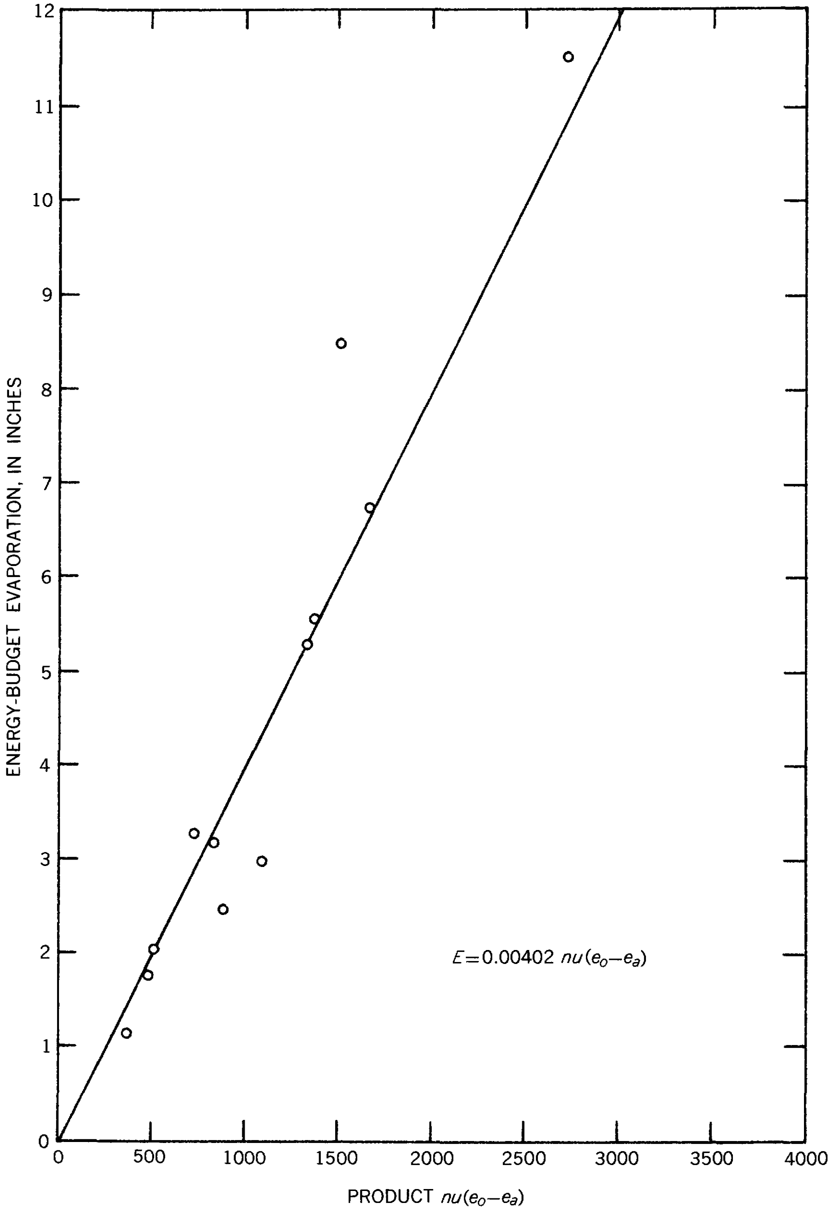

FIGURE 15.—Relation between energy-budget evaporation and the product $nu(e_o-e_a)$ for site 13.

TABLE 6.—*Monthly mass-transfer evaporation for sites 11, 12, and 13 and observed sunken pan evaporation at Denton, Tex.*

Month	Site 11		Site 12		Site 13		Sunken pan (inches)
	Inches	Acre-feet	Inches	Acre-feet	Inches	Acre-feet	
1957							
Oct	4.2	13.2	3.9	5.3	4.5	4.7	3.82
Nov	2.1	7.4	2.1	3.3	1.8	2.3	2.87
Dec	1.7	6.4	1.7	2.7	1.8	2.5	2.61
1958							
Jan	1.5	5.4	1.3	2.2	1.7	2.3	2.22
Feb	2.1	7.6	1.9	3.0	2.3	3.2	2.04
Mar	2.3	8.4	2.7	4.5	2.9	4.1	2.44
Apr	3.3	12.1	3.6	6.0	3.6	5.3	2.94
May	4.1	24.2	5.0	12.4	5.0	9.5	4.72
June	6.9	28.1	7.1	11.4	7.0	9.5	7.23
July	8.1	28.9	7.9	12.2	9.1	11.3	7.41
Aug	7.0	23.2	7.3	10.6	6.9	7.7	7.09
Sept	5.4	17.1	6.5	9.1	6.9	7.0	4.76
Total	48.7	182.0	51.0	86.7	53.5	69.4	50.15
1958							
Oct	3.3	10.3	4.0	5.4	3.6	3.4	3.61
Nov	3.3	9.9	2.8	3.7	3.1	2.8	3.34
Dec	1.9	5.7	2.0	2.6	2.9	2.5	2.25
1959							
Jan	1.9	5.5	2.1	2.7	2.6	2.2	[1] 2.49
Feb	1.9	5.4	1.9	2.4	2.7	2.2	2.36
Mar	5.0	14.0	5.6	7.1	6.9	5.3	4.97
Apr	5.2	14.1	6.1	7.7	6.6	4.9	4.96
May	6.0	18.2	8.1	10.2	8.3	6.0	4.55
June	7.1	18.6	8.3	10.4	8.7	6.2	6.33
July	6.1	16.4	7.7	10.0	8.0	5.7	4.86
Aug	7.3	19.2	8.6	11.1	8.8	6.2	7.05
Sept	6.1	15.1	7.6	9.4	7.0	4.7	5.95
Total	56.0	152.4	64.8	82.7	69.2	52.1	52.72

[1] Adjusted to full month.

The mass-transfer results show that the evaporation rates for the three sites were higher for the second year, October 1958 to September 1959, than for the first year, October 1957 to September 1958. The average temperature of the air for the first year was 64°F and for the second year 63°F, a difference of only 1°F. The average wind speed for each site was almost the same each year. The higher evaporation rate can not be attributed to a change in the climatic conditions. The range in evaporation among the three sites is considerably more the second year than the first year. The reason for this is not known. The only data which are common to the three sites is the vapor pressure of the air. The other data used in the mass-transfer equation were recorded at each site.

Monthly evaporation volumes at the other nine sites were computed for the period October 1957 to September 1959 by using the average monthly rate obtained from table 6 and applying this depth to the average monthly surface area of the pool at the site in question. Results are shown in table 9 (p. 60).

POOL EVAPORATION COMPUTED FROM POOL-STAGE RECORDS

In order to make surface-water budget accounting possible at each site for the period prior to the beginning of the mass-transfer study, values of evaporation for the earlier period were needed. Where possible, computation was made on the basis of pool-stage records.

For a control station, site 12 was selected. Evaporation can be estimated by subtracting the estimated seepage (see these values in section on seepage) from the decrease in stage of the pool during periods of no inflow, outflow, or rainfall. Such computations were made for 57 months of the 7-year period, October 1952 to September 1959, as follows: If the basic records indicated that at least 20 days of the month were free of inflow, outflow, and precipitation, the stage decrease during this period was taken from the chart. This decrease was converted to a monthly value by assuming that evaporation and seepage during days of inflow, outflow, or rainfall was the same as the average daily value observed during the rest of the month. For example, during January 1956 there were 5 days of rain or inflow at site 12. The water surface dropped 0.22 foot during the other 26 days. Seepage was estimated at 0.05 foot for the month. Evaporation for the month was computed as follows:

$$(31/26 \times 0.22) - 0.05 = 0.21 \text{ foot.}$$

Evaporation so estimated probably exceeds the actual evaporation because evaporation rates are assumed to be the same for rainy days as for clear days. However, the possible error appears to be negligible.

Timing of rainfall permitted computation of the evaporation at site 12 from the pool-stage records for 33 of the 60 months prior to the availability of actual evaporation measurements. The results are shown in table 8 (p. 59). The rates computed for site 12 were assumed to apply to all pools. Therefore, the monthly volume of evaporation for each pool was computed using the monthly rate shown in table 8 and the average monthly surface area for the pool at the site in question. The monthly evaporation volume for each site is given in table 9. The values of seepage used in the computations made for site 12 for the 33 months are given in table 13 (p. 65).

COMPARISON OF EVAPORATION BY MASS-TRANSFER AND POOL-STAGE METHODS

Evaporation was computed at site 12 from pool-stage records for 17 of the 24 months for which mass-transfer results were also available. The values for these 17 months, October 1957 and June 1958 to September 1959, as computed by each method were plotted against each other as shown in figure 16. With the exception of the months of June 1958, and April and May 1959, a fair agreement exists.

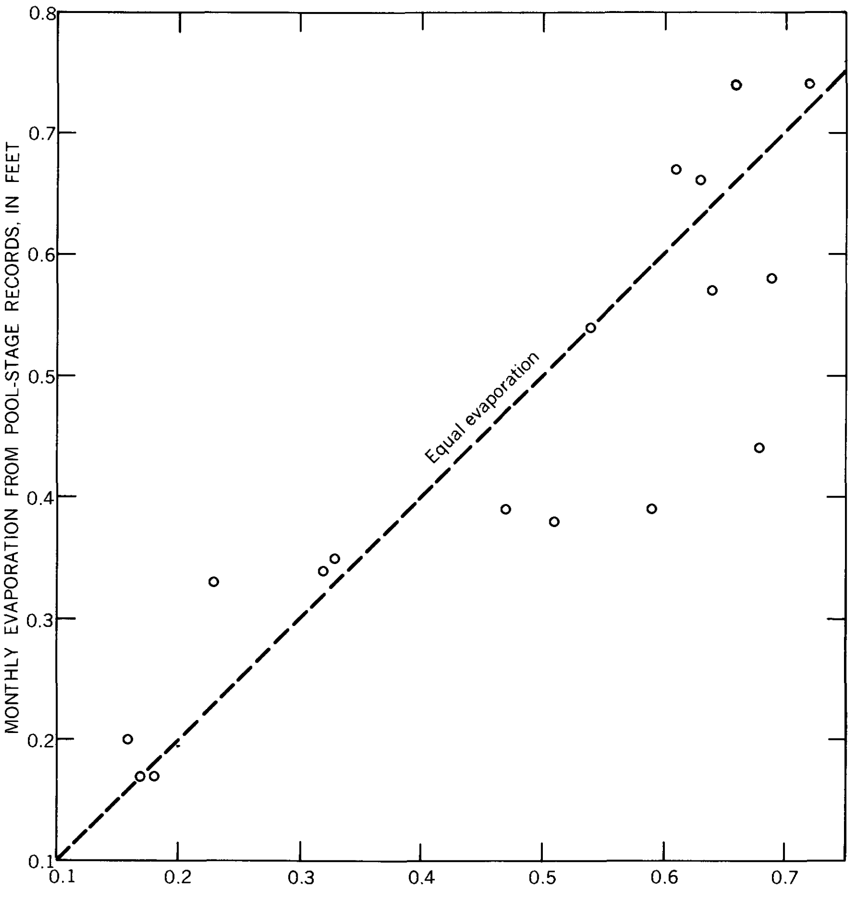

FIGURE 16.—Comparison of monthly evaporation computed by mass-transfer method with that computed from pool-stage records, October 1957, and June 1958 to September 1959.

POOL EVAPORATION ESTIMATED FROM DENTON PAN RECORDS

Since it was not possible to compute the evaporation at site 12 for 27 of the 60 months prior to actual evaporation measurements by use of the pool-stage records, the record of sunken-pan evaporation at the Denton Experiment Station was used. This pan[1] is 24 inches in diameter, 36 inches deep, and is screened.

[1] The 24-inch sunken pan was installed Aug. 1, 1953, and has not been moved since then. Prior to August 1953 a 72-inch sunken pan of unknown depth was employed. This pan was badly rusted near the ground line when it was replaced and may have leaked.

Monthly pan coefficients were computed from the monthly evaporation at site 12, which had been previously computed by the pool-stage and mass-transfer methods. These coefficients are given in table 7. The average monthly coefficients shown were applied to the observed pan evaporation at Denton to estimate 27 of the 60 months' evaporation record at site 12 for the period October 1952 through September 1957. The estimated figures of evaporation depth for these 27 months are given in table 8. These figures of depth were applied to the average monthly pool surface area at each site to estimate the evaporation for the 27 months. These volumes are shown in table 9.

TABLE 7.—*Monthly coefficients for the Denton evaporation pan based on computed evaporation from site 12*

[Pool evaporation for the period August 1953 through September 1957 was obtained from pool-stage records adjusted for estimated seepage. Pool evaporation for October 1957 through September 1959 was measured by the mass-transfer technique]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1953								1.08	0.93	0.89	0.61	0.64
1954							1.01	.97	1.06			
1955						1.20	1.29					.72
1956	0.88		0.83	1.06		1.19	1.01	1.11	.88	.83	.97	.88
1957	1.00						1.10	1.22	.93	1.03	.72	.65
1958	.59	0.95	1.12	1.24	1.06	.99	1.07	1.03	1.35	1.11	.85	.90
1959	.84	.79	1.12	1.22	[1]1.76	1.32	1.57	1.23	1.27			
Average	.83	.87	1.02	1.17	[2]1.17	1.18	1.18	1.11	1.07	.96	.79	.76

[1] This coefficient appears to be an extreme value and was not used to compute an average value for the month of May.
[2] Interpolated between April and June values.

TABLE 8.—*Monthly and annual evaporation, in feet, from site 12 for water years 1953–59*

[Computed from pool-stage record and estimated seepage losses, except as noted]

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1953	0.51	0.16	[1]0.12	[1]0.14	[1]0.16	[1]0.29	[1]0.42	[1]0.54	[1]0.88	0.61	0.67	0.51	5.01
1954	.34	.14	.16	[1].13	[1].28	.28	[1].53	[1].44	[1].66	.78	.79	.63	5.16
1955	[1].39	[1].22	[1].18	[1].17	[1].16	[1].34	[1].47	[1].57	.49	.76	.74	.55	5.04
1956	.54	.41	.21	.21	[1].24	.35	.52	[1].57	.80	.85	.92	.69	6.31
1957	.38	.32	.23	.17	[1].17	[1].28	[1].33	[1].44	[1].59	.63	.79	.43	4.76
1958	[2].32	[2].18	[2].14	[2].11	[2].16	[2].22	[2].30	[2].42	[2].59	[2].66	[2].61	[2].54	4.25
1959	[2].33	[2].23	[2].17	[2].18	[2].16	[2].47	[2].51	[2].68	[2].69	[2].64	[2].72	[2].63	5.41

[1] Estimated from Denton pan evaporation record given in the U.S. Weather Bureau publication, Climatological Data, Texas.
[2] Computed using mass-transfer method.

The coefficients shown in table 7 are strictly applicable only to the 24-inch pan, which was installed Aug. 1, 1953. However, it is believed that the error involved in applying coefficients in table 7 to the monthly evaporation observed from the 6-foot sunken pan that was used at the Denton Experiment Station prior to August 1953 does not exceed about 25 percent. Kohler (1954) [2] for instance,

[2] Kohler, M. A., 1954, Lake and pan evaporation in water-loss investigations—Lake Hefner studies, technical report: U.S. Geological Survey Prof. Paper 269, p. 147.

TABLE 9.—*Monthly and annual evaporation from pools in acre-feet*

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1952													
11	------	------	------	------	------	------	------	------	------	7.8	2.4	2.0	------
12	------	------	------	------	------	------	------	------	------	3.2	1.1	1.0	------
1953													
11	2.4	2.8	5.6	9.2	16.4	25.8	16.1	16.5	12.0	7.5	3.1	3.6	121.0
12	1.2	1.4	2.6	4.2	8.3	11.6	7.6	8.0	6.0	3.9	1.6	1.9	58.3
1954													
11	2.9	6.5	6.4	12.2	14.1	25.0	28.1	24.2	16.9	10.3	5.9	4.6	157.1
12	1.6	3.6	3.5	7.1	8.0	13.0	14.3	14.1	10.9	6.9	4.2	3.4	90.6
1955													
8F	------	------	------	------	------	------	------	------	------	------	3.2	1.5	------
8G	------	------	------	------	------	------	------	------	------	------	2.7	1.3	------
9	------	------	5.0	7.5	9.0	7.5	10.6	9.2	6.2	5.8	3.8	1.8	------
10	------	------	------	------	------	------	------	------	5.1	4.9	3.5	1.7	------
11	4.4	4.5	10.4	15.5	20.5	17.6	24.2	19.4	12.6	12.6	9.0	4.5	155.2
12	3.3	3.2	6.7	9.2	11.2	9.5	14.1	12.8	9.2	8.7	6.4	3.2	97.5
13	------	------	------	------	------	------	------	7.9	5.4	5.0	3.5	1.7	------
14	------	1.9	4.3	6.0	7.2	6.2	9.0	8.3	5.8	5.6	4.0	2.0	------
1956													
8F	1.4	2.6	4.6	6.6	7.8	10.2	10.1	10.1	7.2	3.6	3.1	2.2	69.5
8G	1.2	1.7	2.8	4.5	14.8	19.4	17.1	16.7	11.4	5.9	5.2	3.6	104.3
9	1.7	2.3	3.8	5.4	6.2	7.7	6.9	6.3	4.2	2.2	1.8	1.3	49.8
10	1.7	2.2	3.9	5.7	6.6	8.6	8.4	8.6	5.9	3.1	2.6	1.8	59.1
11	4.3	5.7	10.0	13.9	15.9	21.0	18.7	16.4	10.1	5.1	4.5	3.2	128.8
12	3.2	4.1	6.8	9.7	11.0	14.6	14.3	14.4	10.1	5.3	4.5	3.2	101.2
13	1.6	2.1	3.1	4.4	5.1	6.6	6.4	6.2	5.3	1.7	1.4	.9	44.8
14	1.9	2.5	4.1	5.8	7.1	9.5	9.3	9.1	6.2	3.2	2.7	1.9	63.3
1957													
8C	------	------	------	------	36.6	17.0	13.3	15.6	8.2	7.0	4.0	3.4	------
8F	1.6	1.7	3.1	8.2	19.7	17.5	11.8	13.6	7.0	5.6	3.4	3.0	96.2
8G	2.7	3.0	6.8	18.5	52.6	38.0	19.0	21.2	11.1	9.0	6.4	4.8	193.1
8H	------	------	------	------	25.1	16.0	12.0	13.9	7.3	5.9	3.4	3.0	------
9	.9	.9	1.7	5.4	15.3	12.4	9.3	10.6	5.3	4.2	2.7	2.4	71.1
10	1.4	1.4	2.5	5.7	10.3	8.1	7.0	8.2	4.3	3.4	2.0	1.8	56.1
11	2.4	2.5	4.6	12.7	37.1	45.2	33.3	32.8	16.3	13.2	7.4	6.4	213.9
12	2.3	2.4	4.1	7.8	19.2	15.9	11.8	13.6	7.2	5.3	3.3	2.7	95.6
13	.7	.7	1.4	4.0	13.3	13.9	10.1	11.4	5.7	4.7	2.3	2.5	70.7
14	1.4	1.4	2.4	4.2	7.9	8.1	7.6	8.9	4.7	3.7	2.2	1.9	54.4
1958													
8C	3.0	4.0	5.0	6.9	9.8	13.0	15.1	11.8	9.9	5.2	4.4	3.1	91.2
8D	3.4	4.7	5.8	7.8	11.8	14.5	16.9	12.6	9.5	5.2	4.3	3.1	99.6
8E	4.2	5.7	7.0	9.6	14.5	17.1	18.9	14.2	11.6	6.5	5.4	3.9	118.6
8F	2.6	3.6	4.4	6.1	13.0	11.2	12.7	9.8	8.2	4.6	3.9	2.8	82.9
8G	4.2	5.7	7.2	10.6	21.8	20.2	20.5	15.3	11.9	6.1	5.2	3.7	132.4
8H	2.6	3.6	4.4	6.1	9.4	11.6	13.2	10.1	8.4	4.7	4.1	2.9	81.1
9	2.1	2.9	3.5	4.8	9.5	8.9	10.1	7.8	6.3	3.4	2.8	2.0	64.1
10	1.6	2.1	2.6	3.6	8.7	6.7	7.4	5.5	4.8	2.7	2.3	1.7	49.7
11	5.4	7.6	8.4	12.1	24.2	28.1	28.9	23.2	17.1	10.3	9.9	5.7	180.9
12	2.2	3.0	4.5	6.0	12.4	11.4	12.2	10.6	9.1	5.4	3.7	2.7	83.2
13	2.3	3.2	4.1	5.3	9.5	9.5	11.3	7.7	7.0	3.4	2.8	2.5	68.6
14	1.7	2.3	2.8	3.8	7.6	7.3	8.4	6.8	5.7	3.4	2.9	2.1	54.8

TABLE 9.—*Monthly and annual evaporation from pools in acre-feet*—Continued

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1959													
8C	2.9	2.9	6.0	8.2	10.3	11.0	12.9	14.3	11.2				
8D	2.9	2.9	7.6	7.7	9.4	9.8	13.5	15.7	12.3				
8E	3.5	3.5	9.2	9.7	11.6	12.0	13.3	15.0	11.7				
8F	2.6	2.6	7.2	7.3	9.2	9.7	10.7	11.6	9.2				
8G	3.5	3.4	9.0	8.9	11.2	11.8	20.5	20.8	15.8				
8H	2.7	2.7	7.3	7.4	9.2	9.7	11.9	13.2	10.4				
9	1.8	1.7	4.5	4.6	5.6	5.7	5.7	6.0	4.5				
10	1.5	1.5	4.4	4.6	6.0	6.2	5.9	6.6	5.3				
11	5.5	5.4	14.0	14.1	18.2	18.6	16.4	19.2	15.1				
12	2.7	2.4	7.1	7.7	10.2	10.4	10.0	11.1	9.4				
13	2.2	2.2	5.3	4.9	6.0	6.2	5.7	6.2	4.7				
14	1.9	1.9	5.1	5.2	6.8	5.9	5.9	5.9	5.8				

shows monthly pan-to-pan coefficients for a similar combination of pans as varying from 0-74 to 1.13 through the year.

The 7-year record of evaporation for site 12 is summarized in table 8. The average annual evaporation at site 12 for the 7 years of record was 5.13 feet, and the average annual rainfall at rain gage 14–S was 2.93 feet. Hence, the net annual evaporation loss at site 12 was 2.20 feet.

SEEPAGE FROM POOLS

COMPUTATION OF SEEPAGE AS A RESIDUAL FROM POOL-STAGE RECORDS

During the periods of no inflow or outflow, seepage from a reservoir is equal to the decrease in contents plus rainfall on the pool minus evaporation and transpiration. Measured evaporation was available only during the period of instrumentation, October 1957 to September 1959. Therefore only this period could be considered for use in computing seepage as a residual from the pool-stage records. Excessive outflow or ungaged inflow or both, occurred during this period in all months except July 1958 to February 1959, and August and September 1959. It was possible then to compute seepage for these 10 months from pool-stage records.

Although continuous records of base inflow were not available, once each week, or more frequently, the observer at site 12 reported whether or not there was inflow. He reported flow on only 9 days of the two periods July 1958 through February 1959 and August through September 1959. No surface inflow was observed during 4 of these 10 months. Table 10 illustrates the method used to compute seepage at site 12 employing mass-transfer evaporation, pool-stage records and rainfall data. Such tables were prepared for each site using the respective stage records, rainfall recorded at the nearest rain gage, and evaporation data as shown in table 6. The resulting monthly figures for the seepage at each site for these 10 months are given in table 13.

TABLE 10.—*Computation of seepage rates in feet per month at site 12*

Month and year	Pool recession+	Rainfall	−Evaporation=	Seepage	Air temperature [1] (°F)
	Feet per month				
1958					
July [2]	0.64	0.12	0.66	0.10	85.0
August	.59	.10	.61	.08	85.2
September [2]	.25	.38	.54	.09	77.2
October	.28	.12	.33	.07	65.9
November	.10	.19	.23	.06	57.5
December	.13	.08	.17	.04	43.9
1959					
January [2]	.17	.04	.18	.03	43.8
February	.04	.16	.16	.04	48.8
August [2]	.44	.35	.72	.07	81.5
September	.61	.07	.63	.05	78.2

[1] Average monthly air temperature at McKinney, Tex.
[2] No inflow reported.

The seepage figures so computed are less than the true values by the amounts of unmeasured inflow, both surface and subsurface, and are greater than the true values by the amount of unmeasured transpiration and wetted soil evaporation around the periphery of the pool. Rainfall shown in table 10 is measured at rain gage 14–S about one-half mile southeast of site 12, and might not be the same as at the pool. There is also the slight error caused by assuming that the area of the water surface remains the same during an observation period. Thus the seepage figures presented for these 10 months are the best that can be extracted from the data available.

COMPUTATION OF SEEPAGE FROM PARAMETER OF VISCOSITY

In order to compute pool seepage for those months prior to October 1957 (beginning of evaporation measurements) and for those 14 months when pool-stage records could not be used, a relation between water temperature—thus viscosity—and seepage was used.

A study of the effect of varying water viscosity on seepage rates requires, of course, an estimate of the average monthly temperature of the water at the bottom of a pool. Thermal surveys of site 12 were made at approximately monthly intervals during water year 1958. Temperature profiles were obtained at 18 stations during each survey, and representative profile data are shown in table 11. Monthly average bottom water temperatures for site 12 estimated from such temperatures profiles are listed in table 12 together with the corresponding average monthly air temperatures at McKinney, Tex.

It is unfortunate that with the exception of the last 3 months of water year 1958 site 12 received unmeasured amounts of inflow, thus precluding accurate computation of seepage from pool-stage records. Thus, for most of the periods (July 1958 to February 1959, and August and September 1959) for which seepage computation from

TABLE 11.—*Average water temperatures in °F at the indicated depths below water surface at site 12*

Depth (ft)	1957		1958		
	Sept. 20	Nov. 25	Feb. 2	Mar. 30	Aug. 12
0	79. 3	47. 4	48. 0	54. 5	89. 4
0.5	79. 2	47. 3	48. 0	54. 5	89. 1
1	79. 2	47. 2	48. 0	54. 5	87. 7
2	79. 0	46. 9	48. 0	54. 5	86. 3
4	78. 1	46. 6	47. 9	54. 5	84. 3
6	77. 1	46. 2	47. 9	54. 5	82. 9
8	75. 7	45. 8	47. 8	54. 5	81. 8
10	74. 4	45. 6	47. 9	54. 5	81. 1
12	--------	45. 1	47. 9	54. 5	--------

TABLE 12.—*Average monthly bottom water temperature at site 12 and corresponding average monthly air temperature at McKinney, Tex., for water year 1958*

Month and year	Average bottom water temperature (°F)	Average air temperature at McKinney, Tex. (°F)
1957		
Octcber	65. 8	62. 1
November	51. 3	52. 3
December	48. 2	52. 0
1958		
January	48. 9	45. 2
February	48. 2	44. 7
March	50. 9	49. 4
April	57. 9	62. 0
May	65. 1	73. 4
June	75. 6	81. 2
July	79. 2	85. 0
August	82. 0	85. 2
September	74. 5	77. 2

pool-stage records are available, directly observed bottom water temperatures are not available. However, figure 17, which is a plot of the data shown in table 12, indicates that a fairly good linear relation exists between the average monthly bottom water temperature of site 12 and the average monthly air temperature at McKinney, Tex. Therefore seepage values from table 10 have been plotted against McKinney air temperatures on figure 18. The line of relation shown on this graph was positioned by giving approximately equal weight to the plotted points and to the assumption that seepage should vary inversely with the viscosity of the water.

To illustrate that the relation of figure 18 does conform to the above assumption, two bottom water temperatures were selected, 50° and 86°, for which the corresponding specific viscosities of water are 0.730 and 0.446. From figure 17 the monthly mean air temperatures

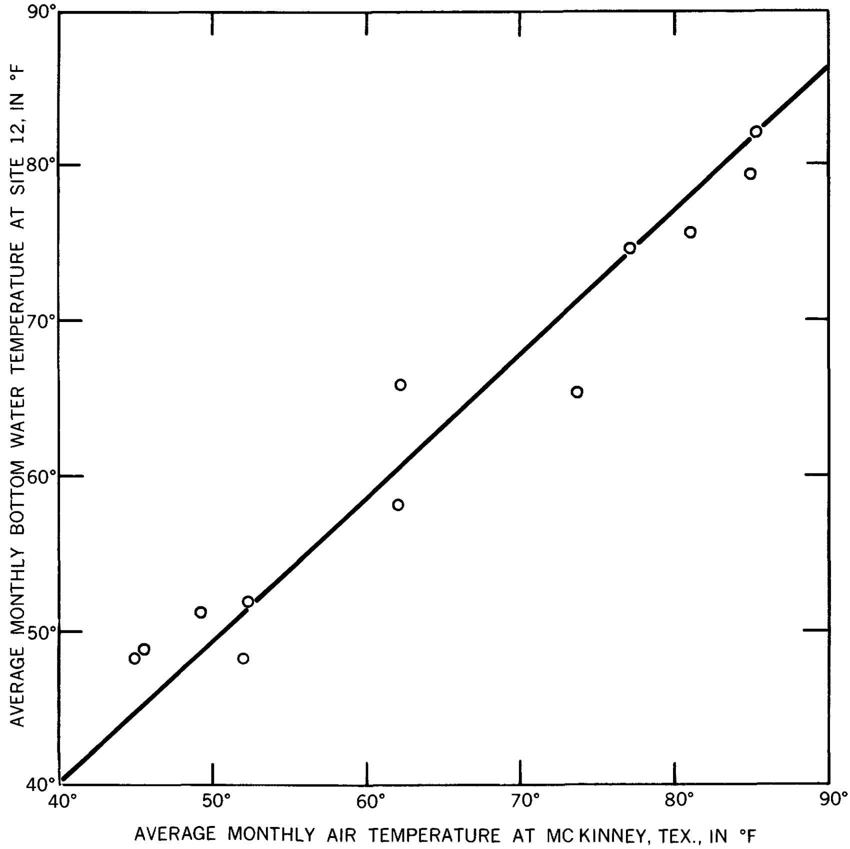

FIGURE 17.—Relation between average monthly air temperature at McKinney, Tex., and average monthly bottom water temperature at site 12, water year 1958.

at McKinney corresponding to these water temperatures are 51.0° and 89.8°. Entering figure 18 with these latter temperatures one obtains seepage rates of 0.050 and 0.087 feet per month. The ratio of the two seepage rates, $\frac{0.050}{0.087}$, is 0.57 and the inverse ratio of the two viscosities, $\frac{0.446}{0.730}$, is 0.61. The two ratios agree within 7 percent.

Diagrams like figure 18 were prepared for each of the other pond sites. Those prepared for sites with only staff-gage records are probably not as accurate as those for sites 11 and 12. Weekly observations of base inflow to the pools were not available at the staff-gage sites. Since considerable weight was given the relation of viscosity and seepage in drawing the figures these inaccuracies were lessened. The relation may be considered as seepage rating curves based on the

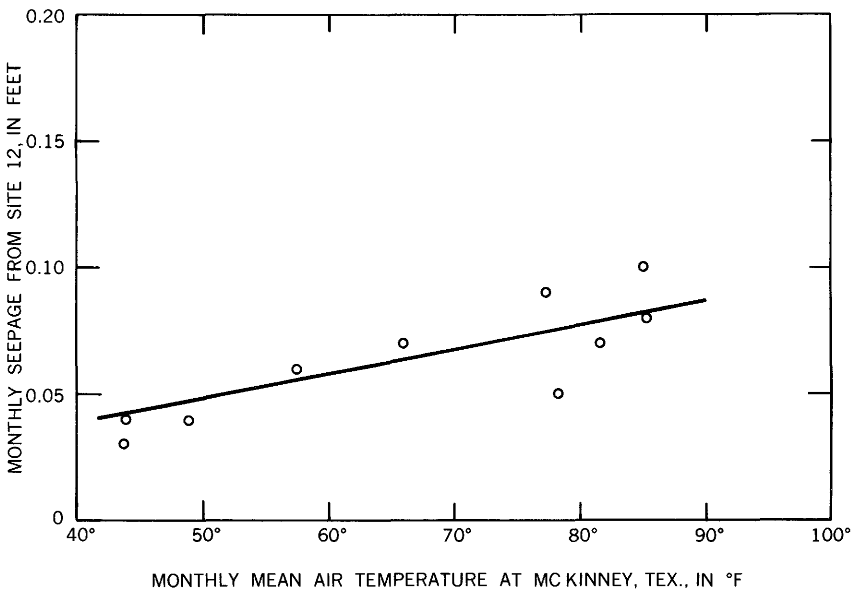

FIGURE 18.—Relation of monthly seepage from site 12 to monthly mean air temperature at McKinney, Tex., July 1958 to February 1959, August and September 1959.

mean of the observed basic seepage data (exemplified by table 10) and the inverse relation of seepage and viscosity. These curves together with records of monthly mean air temperatures at McKinney were used to compute monthly seepage rates for the period of record at each site prior to July 1958, and for the period March to July 1959. These rates were in turn multiplied by the average monthly surface area of the pool to obtain monthly volumes of water seeping from the pool. The results, presented in table 13, were used in computing the evaporation from pool-stage records as described in an earlier section.

The areal variation of monthly seepage among the sites in Honey Creek basin when the bottom water temperature is 45°F is given in figure 19. Annual seepage totals vary from 0.8 to 4.6 feet among the several sites.

TABLE 13.—*Monthly and annual seepage, in acre-feet*

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						1952							
11	------	------	------	------	------	------	------	------	------	3.2	2.7	2.8	--------
12	------	------	------	------	------	------	------	------	------	.4	.3	.4	--------
						1953							
11	2.9	3.2	3.7	4.2	6.7	7.9	6.9	6.4	5.7	4.7	4.0	3.8	60.1
12	.4	.4	.5	.6	.9	1.1	1.0	1.0	.8	.7	.6	.6	8.6

TABLE 13.—*Monthly and annual seepage, in acre-feet*—Continued

Site	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1954													
11	3.8	4.2	4.1	4.9	6.7	9.5	10.1	8.3	6.7	5.5	4.8	4.4	73.0
12	.6	.6	.7	.8	1.1	1.4	1.5	1.4	1.2	1.1	1.0	1.0	12.4
1955													
8F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.4	0.4	-----
8G	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.7	1.5	-----
9	-----	-----	3.3	4.1	4.4	4.5	4.5	4.0	3.4	2.7	2.1	1.8	-----
10	-----	-----	-----	-----	-----	-----	-----	-----	1.9	1.5	1.3	1.1	-----
11	4.4	4.4	5.5	6.9	8.3	8.6	8.3	6.8	5.5	4.9	4.0	3.6	71.2
12	1.0	1.0	1.0	1.2	1.4	1.4	1.5	1.4	1.2	1.0	.8	.8	13.7
13	-----	-----	-----	-----	-----	-----	-----	4.7	4.1	3.2	2.6	2.4	-----
14	-----	.6	.6	.8	.9	.9	1.0	.9	.7	.6	.5	.5	-----
1956													
8F	0.3	0.5	0.7	0.8	1.0	0.9	1.0	0.9	0.7	0.6	0.5	0.5	8.4
8G	1.5	1.8	2.1	2.5	8.8	9.0	8.0	7.3	6.0	5.0	4.2	4.1	60.3
9	1.7	2.0	2.5	2.5	3.1	3.0	2.8	2.3	1.8	1.5	1.2	1.2	25.6
10	1.1	1.3	1.7	1.7	2.2	2.3	2.3	2.0	1.7	1.4	1.1	1.1	19.9
11	3.5	4.1	5.1	5.4	6.4	6.6	6.2	4.8	3.7	3.0	2.6	2.5	53.9
12	.8	.9	1.0	1.1	1.1	1.3	1.3	1.3	1.0	.8	.7	.7	12.0
13	2.3	2.4	2.8	2.9	3.6	3.5	3.5	3.1	3.2	1.7	1.4	1.2	31.6
14	.5	.5	.6	.7	.9	.8	.9	.8	.6	.5	.4	.4	7.6
1957													
8C	-----	-----	-----	-----	21.6	8.4	6.8	6.1	5.1	5.2	5.0	4.6	-----
8F	0.5	0.5	0.6	1.5	2.7	2.1	1.5	1.4	1.1	1.0	1.0	1.0	14.9
8G	4.0	4.6	6.4	16.2	38.2	23.2	12.0	10.4	8.8	8.2	9.8	8.1	149.9
8H	-----	-----	-----	-----	15.4	8.1	6.5	5.6	4.7	4.6	4.4	4.2	-----
9	1.2	1.2	1.3	3.9	9.4	6.3	5.0	4.3	3.4	3.2	3.4	3.4	46.0
10	1.1	1.2	1.4	2.7	4.2	2.8	2.5	2.3	1.9	1.8	1.6	1.7	25.2
11	2.4	2.6	2.9	7.7	18.5	19.2	14.2	10.8	8.7	8.2	7.8	7.5	110.5
12	.7	.7	.7	1.4	2.6	1.9	1.5	1.4	1.2	1.0	1.0	1.0	15.1
13	1.1	1.3	1.6	4.0	11.5	10.0	7.5	6.5	5.1	4.6	4.6	5.0	62.8
14	.4	.4	.4	.8	1.1	1.0	1.0	.9	.7	.6	.6	.6	8.5
1958													
8C	4.6	4.5	4.8	5.5	6.6	6.5	6.7	6.4	5.5	4.2	3.7	3.3	62.3
8D	5.3	5.2	5.5	6.2	7.9	7.2	7.5	6.8	5.3	4.2	3.7	3.3	68.1
8E	4.5	4.4	4.8	5.3	6.7	6.2	5.7	5.3	4.5	3.6	3.1	2.9	57.0
8F	1.0	1.0	1.0	1.2	2.0	1.4	1.5	1.3	1.1	.9	.8	.8	14.0
8G	8.2	8.0	8.5	10.6	17.9	12.8	11.1	10.4	8.2	6.2	5.4	4.9	112.2
8H	4.3	4.2	4.4	5.0	6.5	6.2	6.0	5.8	4.9	4.0	3.6	3.2	58.1
9	3.4	3.4	3.5	4.0	6.5	4.8	4.6	4.4	3.6	2.8	2.5	2.2	45.7
10	1.7	1.7	1.8	2.0	4.0	2.4	2.2	2.0	1.8	1.5	1.3	1.2	23.6
11	7.5	7.5	8.0	9.0	15.6	12.2	11.0	10.8	9.2	7.4	6.5	6.0	110.7
12	1.0	1.0	1.0	1.2	1.8	1.3	1.5	1.4	1.2	1.0	.8	.8	14.0
13	5.0	5.0	5.1	5.8	8.5	7.0	6.6	6.2	5.2	4.1	3.5	3.0	65.0
14	.6	.6	.6	.8	1.2	.9	1.0	.9	.8	.7	.6	.5	9.2
1959													
8C	3.3	3.3	3.4	3.8	4.3	4.8	6.2	6.2	5.4	-----	-----	-----	-----
8D	3.3	3.2	3.3	3.5	3.9	4.3	6.4	6.8	5.9	-----	-----	-----	-----
8E	2.7	2.7	2.8	2.9	3.4	3.6	4.4	4.6	4.0	-----	-----	-----	-----
8F	.7	.7	.7	.9	1.0	1.0	1.2	1.2	1.1	-----	-----	-----	-----
8G	4.8	4.8	5.0	5.2	5.9	6.3	12.9	11.1	9.6	-----	-----	-----	-----
8H	3.2	3.2	3.3	3.6	4.0	4.4	6.1	5.9	5.4	-----	-----	-----	-----
9	2.1	2.0	2.0	2.2	2.4	2.6	2.9	2.7	2.3	-----	-----	-----	-----
10	1.2	1.2	1.4	1.5	1.8	1.9	1.9	2.0	1.8	-----	-----	-----	-----
11	5.9	5.8	6.1	6.6	7.3	7.9	8.0	7.9	7.2	-----	-----	-----	-----
12	.8	.8	.8	.9	1.1	1.1	1.1	1.1	1.0	-----	-----	-----	-----
13	2.9	2.9	2.9	3.0	3.4	3.6	3.7	3.6	3.3	-----	-----	-----	-----
14	.5	.5	.5	.6	.7	.7	.7	.7	.7	-----	-----	-----	-----

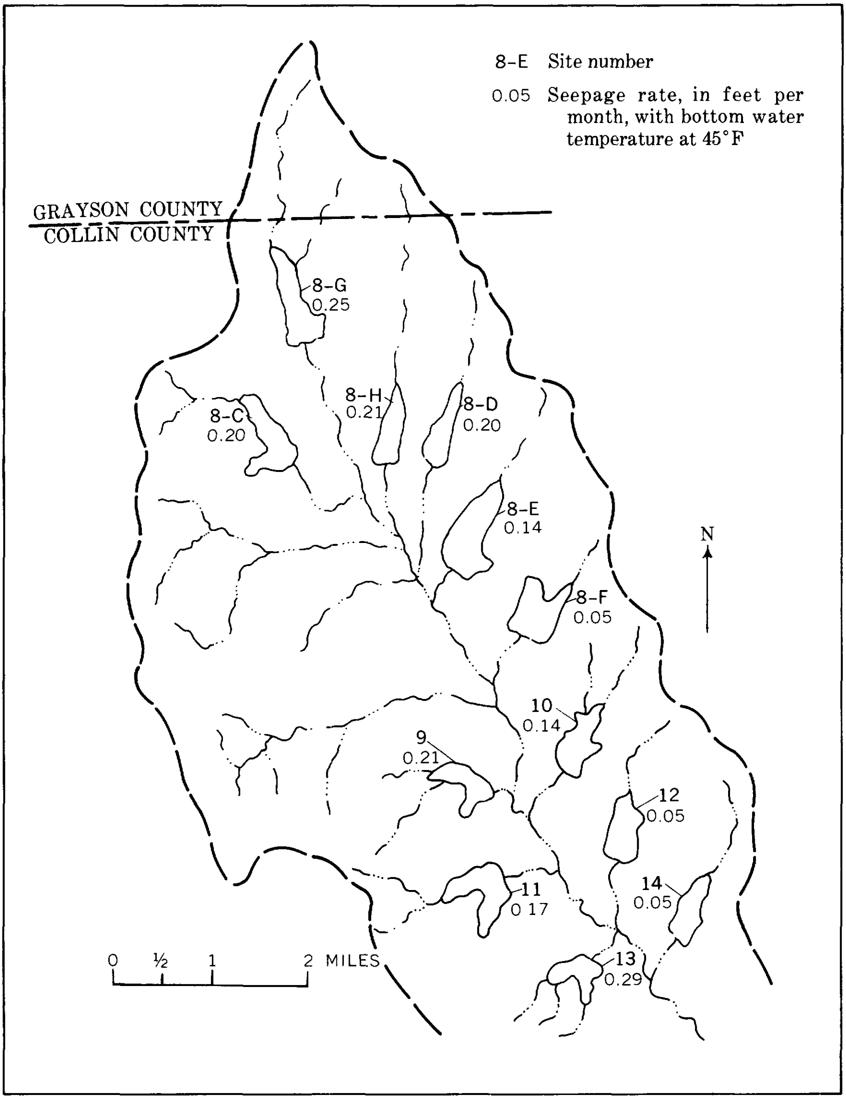

FIGURE 19.—Map of Honey Creek basin showing areal variation of monthly pool seepage, in feet.

What becomes of the water seeping from the pools? Undoubtedly some water passes under or around each of the earthen dams. No measurements of flow were made in the channels immediately below the dams when the pools were not spilling, but during rainless periods the flow is zero at the stream-gaging station about 1 mile below site 14. This would imply that no significant amount of seepage water is passing from the pools into the drainage systems below them. To explore this matter a little further, it may be pointed out that during the month of December 1955, the estimated seepage from the lower six pond sites, Nos. 9 to 14, was 10.2 acre-feet. The area of the drainage channel bottoms between these sites and the stream gage is about 11 acres. Pool evaporation for the month was estimated to be 0.18 foot. Evaporation from a wetted channel bottom would probably be considerably less than that from a pool because the channels are deeply incised and bordered by a dense protecting fringe of trees. However, if the pool evaporation figure of 0.18 foot is used, channel evaporation would be only 2 acre-feet. Transpiration by riparian vegetation is negligible during December. Hence, there remains about 8 acre-feet of seepage water to be accounted for. No surface flow passed the stream gage that month. Therefore the major portion of the pool seepage must be passing through cracks and fissures in the underlying Austin Chalk formation to enter the regional body of ground water.

DATA SUMMARY

SURFACE-WATER BUDGET OF GAGED WATERSHEDS

Given in table 14 is the surface-water budget summary for the gaged watersheds on a monthly and annual basis covering water years 1953–59. The headings to the different items of the table are for the most part self explanatory. The figures given for "total inflow" include rainfall on the pool computed at the time of occurrence. Also the figures given for "total discharge through the outlets" include purposely discharged water through the 8-inch drains. "Pool consumption" combines evaporation and seepage into one item of the budget and includes transpiration.

EFFECTS OF FLOODWATER-RETARDING POOLS ON FLOW REGIMEN

EFFECTS ON RUNOFF

In 1951, two floodwater-retarding structures existed in the study area. Others were completed at intervals thereafter until a total of 12 existed in July 1957. Table 14 presents surface-water budget information for these watersheds, the extent of coverage being progressively enlarged as new structures were completed. Since only two years of data are available for complete development conditions, a comprehensive analysis as to the effects on runoff at downstream points attributable to the structures is not attempted in this report. Such an analysis would require much more data.

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
OCTOBER 1952							
Controlled drainage area, 7.82 sq mi							
[Gaged area, 3.40 sq mi]							
11	−11.2	0.2	0.4	[1] 0.15	16	0.2	11.0
12	−4.2	.1	.7	[1] .15	7.5	.1	3.6
Total	−15.4	0.3	1.1	0.15	24	0.3	14.6
Uncontrolled drainage area, 31.2 sq mi							
Stream-gaging station flow, acre-feet							0
NOVEMBER							
11	+10.3	15.4	0	[1] 7.40	16	9.9	5.1
12	+12.6	14.0	0	[1] 7.40	8	4.9	1.4
Total	+22.9	29.4	0	7.40	24	14.8	6.5
Stream-gaging station flow, acre-feet							79.0
DECEMBER							
11	+10.7	16.3	0	[1] 3.09	17	4.4	5.6
12	+14.6	20.0	3.6	[1] 3.09	9	2.3	1.8
Total	+25.3	36.3	3.6	3.09	26	6.7	7.4
Stream-gaging station flow, acre-feet							140
1952 calendar year total	-------	-------	-------	-------	-------	-------	-------
JANUARY 1953							
11	+2.8	8.6	0	[1] 0.76	17	1.1	5.8
12	−4.0	1.0	3.1	[1] .76	10	.6	1.9
Total	−1.2	9.6	3.1	0.76	27	1.7	7.7
Stream-gaging station flow, acre-feet							80.0
FEBRUARY							
11	+5.0	11.4	0	[1] 1.69	17	2.4	6.4
12	+.3	2.8	.5	[1] 1.69	10	1.4	2.0
Total	+5.3	14.2	.5	1.69	27	3.8	8.4
Stream-gaging station flow, acre-feet							70.0

[1] Rainfall at U.S. Weather Bureau station at McKinney, Tex.

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
MARCH							
11	+28.4	37.7	0	[1] 3.19	19	5.1	9.3
12	+1.8	8.0	3.1	[1] 3.19	10	2.7	3.1
Total	+30.2	45.7	3.1	3.19	29	7.8	12.4
Stream-gaging station flow, acre-feet							289
APRIL							
11	+77.8	91.2	0	[1] 7.74	20	12.9	13.4
12	+76.8	94.6	13.0	[1] 7.74	11	6.4	4.8
Total	+154.6	186	13.0	7.74	31	19.3	18.2
Stream-gaging station flow, acre-feet							2,610
MAY							
11	+47.2	109	38.8	[1] 3.10	30	7.8	23.1
12	−13.9	75.1	79.8	[1] 3.10	18	4.6	9.2
Total	+33.3	184	119	3.10	48	12.4	32.3
Stream-gaging station flow, acre-feet							2,850
JUNE							
11	−38.9	4.5	9.7	[1] 0.29	29	0.7	33.7
12	−21.8	2.3	11.4	[1] .29	14	.3	12.7
Total	−60.7	6.8	21.1	0.29	43	1.0	46.4
Stream-gaging station flow, acre-feet							51.0
JULY							
11	−26.1	8.9	12.0	3.03	26	6.6	23.0
12	−3.0	5.6	0	3.03	14	3.5	8.6
Total	−29.1	14.5	12.0	3.03	40	10.1	31.6
Stream-gaging station flow, acre-feet							2.2
AUGUST							
11	−22.2	5.2	4.5	2.56	24	5.1	22.9
12	−6.9	2.7	.6	2.45	13	2.7	9.0
Total	−29.1	7.9	5.1	2.50	37	7.8	31.9
Stream-gaging station flow, acre-feet							0

[1] Rainfall at U.S. Weather Bureau station at McKinney, Tex.

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
SEPTEMBER							
11	−13.6	8.5	4.4	1.63	23	3.1	17.7
12	−3.7	3.2	.1	2.72	13	2.9	6.8
Total	−17.3	11.7	4.5	2.18	36	6.0	24.5
Stream-gaging station flow acre-feet							0
1952–53 water year total	+118.8	546	186	35.12	33	91.7	242
							6,170
OCTOBER							
11	−10.3	6.6	0	3.77	21	6.6	16.9
12	−.9	3.7	0	3.23	13	3.5	4.6
Total	−11.2	10.3	0	3.50	34	10.1	21.5
Stream-gaging station flow acre-feet							97.0
NOVEMBER							
11	+2.9	10.0	0	3.19	21	5.6	7.1
12	+2.9	5.1	0	3.59	13	3.9	2.2
Total	+5.8	15.1	0	3.39	34	9.5	9.3
Stream-gaging station flow acre-feet							111
DECEMBER							
11	−0.7	6.9	0	1.55	21	2.7	7.6
12	+2.4	4.9	0	1.51	13	1.6	2.5
Total	+1.7	11.8	0	1.53	34	4.3	10.1
Stream-gaging station flow acre-feet							17.0
1953 calendar year total	+82.3	518	181	32.90	35	93.8	254
							6,180
JANUARY 1954							
11	+12.7	20.1	0	2.24	22	4.1	7.4
12	+9.2	11.8	0	2.10	13	2.3	2.6
Total	+21.9	31.9	0	2.17	35	6.4	10.0
Stream-gaging station flow acre-feet							378

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
FEBRUARY							
11	+0.7	12.3	0	0.39	22	0.7	11.6
12	+2.1	6.8	0	.44	14	.5	4.7
Total	+2.8	19.1	0	0.42	36	1.2	16.3
Stream-gaging station flow, acre-feet							68.0
MARCH							
11	−8.6	2.4	0	0.70	22	1.3	11.0
12	−1.0	3.2	0	.45	14	.5	4.2
Total	−9.6	5.6	0	0.58	36	1.8	15.2
Stream-gaging station flow, acre-feet							17.0
APRIL							
11	+40.9	58.0	0	5.33	23	10.2	17.1
12	+32.1	40.0	0	4.94	15	6.2	7.9
Total	+73.0	98.0	0	5.14	38	16.4	25.0
Stream-gaging station flow, acre-feet							1,040
MAY							
11	+117.2	138	0	5.18	30	13.0	20.8
12	+64.4	100	27.0	5.34	20	8.9	9.1
Total	+181.6	238	27.0	5.26	50	21.9	29.9
Stream-gaging station flow, acre-feet							2,030
JUNE							
11	+20.3	54.8	0	3.53	36	10.6	34.5
12	−4.7	46.7	37.0	3.93	22	7.2	14.4
Total	+15.6	102	37.0	3.73	58	17.8	48.9
Stream-gaging station flow, acre-feet							1,040
JULY							
11	−56.7	8.5	24.0	2.92	35	8.5	41.2
12	−15.2	3.1	0	1.77	21	3.1	18.3
Total	−71.9	11.6	24.0	2.34	56	11.6	59.5
Stream-gaging station flow, acre-feet							0

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
AUGUST							
11	−42.8	6.1	12.9	2.43	30	6.1	36.0
12	−5.3	10.2	0	2.75	20	4.6	15.5
Total	−48.1	16.3	12.9	2.59	50	10.7	51.5
Stream-gaging station flow, acre-feet							0.6
SEPTEMBER							
11	−38.2	19.0	30.2	4.42	26	9.6	27.0
12	+14.9	27.0	0	5.07	19	8.0	12.1
Total	−23.3	46.0	30.2	4.74	45	17.6	39.1
Stream-gaging station flow, acre-feet							99.0
1953–54 water year total	+138.3	606	131	35.39	42	129	336
							4,900
OCTOBER — Controlled drainage area, 7.82 sq mi; all gaged							
9 [2]	+6.0	16.0	0	4.30	15	5.4	10.0
10 [2]	+42.0	60.0	10.0	4.30	13	4.7	8.0
11	+9.6	25.9	0	4.30	27	9.7	16.3
12	+3.1	66.0	54.5	4.26	19	6.8	8.4
13 [2]	+36.0	45.0	0	4.26	8	2.8	9.0
14 [2]	+38.5	45.0	0	4.26	8	2.8	6.5
Total	+135.2	258	64.5	4.28	90	32.2	58.2
Steam-gaging station flow, acre-feet							403
NOVEMBER							
9 [2]	−6.5	1.5	0	0.88	14	1.0	8.0
10 [2]	−2.0	3.0	0	.88	14	1.0	5.0
11	−8.0	4.3	0	.88	27	2.0	12.3
12	+3.0	9.4	0	.93	21	1.6	6.4
13 [2]	−6.0	2.0	0	.93	9	.7	8.0
14 [2]	−3.0	2.0	0	.93	11	.9	5.0
Total	−22.5	22.2	0	0.90	96	7.2	44.7
Steam-gaging station flow, acre-feet							24.0

[2] Estimated on basis of record for adjacent sites.

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
DECEMBER							
9 [2]	−3.5	2.5	0	1.48	14	1.7	6.0
10 [2]	+1.0	4.0	0	1.48	14	1.7	3.0
11	−4.5	6.1	0	1.48	26	3.2	10.6
12	+1.5	7.1	0	1.26	21	2.2	5.6
13 [2]	−2.0	3.0	0	1.26	9	.9	5.0
14	0	3.0	0	1.26	11	1.2	3.0
Total	−7.5	25.7	0	1.37	95	10.9	33.2
Steam-gaging station flow ... acre-feet							54.0
1954 calendar year total	+247.2	874	196	33.52	57	156	432
							5,150
JANUARY 1955							
9 [2]	+1.0	4.5	0	1.84	14	2.1	5.5
10 [2]	+12.0	15.0	0	1.84	16	2.5	3.0
11	+4.5	14.4	0	1.84	26	4.0	9.9
12	+3.0	21.1	13.0	1.96	22	3.6	5.1
13 [2]	+11.0	15.0	0	1.96	9	1.5	4.0
14	+12.0	15.0	0	1.96	12	2.0	3.0
Total	+43.5	85.0	13.0	1.90	99	15.7	30.5
Steam-gaging station flow ... acre-feet							186
FEBRUARY							
9	+30.0	35.0	0	2.97	16	3.9	5.0
10 [2]	+12.0	55.0	39.0	2.97	17	4.2	4.0
11	+45.2	54.9	0	2.97	28	6.9	9.7
12	+1.7	67.5	61.0	2.61	22	4.8	4.8
13 [2]	+7.0	13.0	0	2.61	10	2.2	6.0
14	+10.1	13.0	0	2.61	12	2.6	2.9
Total	+106.0	238	100	2.79	105	24.6	32.4
Stream-gaging station flow ... acre-feet							1,270
MARCH							
9	+17.9	43.0	16.8	2.67	17	3.6	8.3
10 [2]	+3.0	55.0	46.0	2.67	17	3.8	6.0
11	+43.9	59.8	0	2.67	31	6.9	15.9
12	+2.4	58.1	48.0	2.97	22	5.4	7.7
13 [2]	+21.0	30.0	0	2.97	10	2.5	9.0
14	+4.9	28.8	19.0	2.97	14	3.4	4.9
Total	+93.1	275	130	2.82	111	25.6	51.8
Stream-gaging station flow ... acre-feet							658

[2] Estimated on basis of record for adjacent sites.

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
APRIL							
9	−5.9	26.3	20.6	1.54	17	2.2	11.6
10 [2]	−3.0	30.0	25.0	1.54	17	2.2	8.0
11	+16.9	38.3	0	1.54	34	4.4	22.4
12	−4.6	44.8	39.0	1.88	22	3.4	10.4
13 [2]	+5.0	15.0	0	1.88	11	1.7	10.0
14	−1.8	16.2	11.2	1.88	14	2.3	6.8
Total	+6.6	171	95.8	1.71	115	16.2	69.2
Stream-gaging station flow……acre-feet							457
MAY							
9	0	19.0	5.6	4.97	17	7.0	13.4
10 [2]	−3.0	30.0	25.0	4.97	17	7.0	8.0
11	+16.4	45.2	0	4.97	34	14.1	28.8
12	−1.1	34.5	23.0	4.15	22	7.6	12.6
13 [2]	+29.0	40.0	0	4.15	13	4.6	11.0
14	+.6	41.9	33.2	4.15	15	5.1	8.1
Total	+41.9	211	86.8	4.56	118	45.4	81.9
Stream-gaging station flow……acre-feet							471
JUNE							
9	−9.6	3.9	0	2.33	17	3.3	13.5
10 [2]	−7.4	5.5	2.0	2.33	16	3.1	10.9
11	−25.1	6.6	5.5	2.33	34	6.6	26.2
12	−4.5	6.4	0	2.47	21	4.3	10.9
13 [2]	−8.0	4.0	0	2.47	14	2.9	12.0
14	−5.1	2.8	.2	2.47	13	2.7	7.7
Total	−59.7	29.2	7.7	2.40	115	22.9	81.2
Stream-gaging station flow……acre-feet							173
JULY **Controlled drainage area, 13.2 sq mi** [Gaged area, 7.82 sq mi]							
9	−15.7	1.6	0	1.05	16	1.5	17.3
10	−16.5	2.1	2.0	1.05	14	1.3	16.6
11	−61.5	2.7	31.7	1.05	31	2.7	32.5
12	−15.5	1.2	0	.75	20	1.2	16.7
13	−21.5	2.6	0	.75	12	.8	24.1
14	−9.5	.9	0	.75	12	.8	10.4
Total	−140.2	11.1	33.7	0.90	105	8.3	118
Uncontrolled drainage area, 25.8 sq mi							
Stream-gaging station flow……acre-feet							3.4

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
AUGUST							
9	−15.9	0.5	0	0.38	15	0.5	16.4
10	−15.5	.4	2.0	.38	13	.4	13.9
11	−62.9	.8	34.0	.38	26	.8	29.2
12	−15.4	.5	0	.31	19	.5	15.9
13	−13.1	.8	0	.31	11	.3	13.9
14	−9.2	.3	0	.31	11	.3	9.5
Total	−132.0	3.3	36.0	0.34	95	2.8	98.8
Stream-gaging station flow ... acre-feet							0
SEPTEMBER							
9	−3.7	7.8	0	4.58	13	4.9	11.5
10	−4.1	8.6	2.0	4.58	12	4.6	10.7
11	+2.7	25.0	3.5	4.58	24	9.2	18.8
12	−4.6	6.0	0	4.01	18	6.0	10.6
13	−5.6	5.8	0	4.01	10	3.3	11.4
14	+.9	9.4	0	4.01	10	3.5	8.5
Total	−14.4	62.6	5.5	4.30	87	31.5	71.5
Stream-gaging station flow ... acre-feet							0
1954–55 water year total	+50.0	1,392	573	28.27	103	243	771
							3,700
OCTOBER — Controlled drainage area, 13.2 sq mi; all gaged							
8F	−4.3	0.4	0	0.49	7	0.3	4.7
8G	−4.2	.6	0	.83	5	.3	4.8
9	−12.9	4.8	0	.65	13	.7	17.7
10	−12.5	.8	2.0	.65	12	.7	11.3
11	−16.2	1.8	0	.65	24	1.3	18.0
12	−9.9	.8	0	.56	18	.8	10.7
13	−9.8	.5	0	.56	10	.5	10.3
14	−9.1	1.1	0	.56	11	.5	10.2
Total	−78.9	10.8	2.0	0.62	100	5.1	87.7
Stream-gaging station flow ... acre-feet							0
NOVEMBER							
8F	−2.4	1.2	0	0.61	6	0.3	3.6
8G	−2.0	2.4	0	.55	5	.2	4.4
9	−6 6	1.0	0	.57	11	.5	7.6
10	−6 9	.4	2.0	.57	9	.4	5.3
11	−11.6	1.4	0	.57	23	1.1	13.0
12	−6 0	1.4	0	.62	17	.9	7.4
13	−6 6	.6	0	.62	10	.5	7.2
14	−3.8	1.1	0	.62	10	.5	4.9
Total	−45.9	9.5	2.0	0.59	91	4.4	53.4
Stream-gaging station flow ... acre-feet							0

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
DECEMBER							
8F	−1.1	0.8	0	0.22	6	0.1	1.9
8G	−1.3	1.5	0	.20	5	.1	2.8
9	−4.5	.2	0	.20	10	.2	4.7
10	−2.5	1.8	1.5	.20	8	.1	2.8
11	−7.4	.7	0	.20	22	.4	8.1
12	−4.0	.3	0	.22	17	.3	4.3
13	−5.0	.2	0	.22	10	.2	5.2
14	−2.2	.3	0	.22	9	.2	2.5
Total	−28.0	5.8	1.5	0.21	87	1.6	32.3
Stream-gaging station flow, acre-feet							0
1955 calendar year total	−208.0	1,112	514	23.14	102	204	809
							3,220
JANUARY 1956							
8F	−0.2	1.8	0	0.93	6	0.3	2.0
8G	+.5	3.2	0	1.01	4.5	.4	2.7
9	−2.6	1.5	0	.82	10	.7	4.1
10	−.6	2.2	0	.82	8	.6	2.8
11	−3.4	4.4	0	.82	21	1.4	7.8
12	−.2	3.8	0	1.07	16	1.4	4.0
13	−2.9	1.4	0	1.07	9	.8	4.3
14	−.7	1.7	0	1.07	9	.8	2.4
Total	−10.1	20.0	0	0.95	83.5	6.4	30.1
Stream-gaging station flow, acre-feet							0
FEBRUARY							
8F	+42.8	46.3	0	4.91	9	3.1	3.5
8G	+6.0	9.8	0	3.90	5	1.6	3.8
9	+29.6	34.3	0	5.14	12	4.7	4.7
10	+59.2	63.1	0	5.14	10	4.0	3.9
11	+96.5	107	0	5.14	25	10.7	10.8
12	+60.1	80.8	15.0	4.63	20	7.7	5.7
13	+19.3	24.1	0	4.63	10	3.5	4.8
14	+27.0	30.4	0	4.63	10	3.6	3.4
Total	+340.5	396	15.0	4.76	101	38.9	40.6
Stream-gaging station flow, acre-feet							695
MARCH							
8F	−3.7	1.6	0	0.38	12	0.4	5.3
8G	−1.2	3.7	0	.27	6	.1	4.9
9	−7.6	.6	0	.37	13	.4	8.2
10	−5.2	.6	0	.37	16	.5	5.8
11	−11.4	3.7	0	.37	29	.9	15.1
12	−8.0	.8	1.0	.43	21	.8	7.8
13	−6.2	.4	0	.43	10	.4	6.6
14	−4.6	.4	0	.43	11	.4	5.0
Total	−47.9	11.8	1.0	0.38	118	3.9	58.7
Stream-gaging station flow, acre-feet							1.4

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
APRIL							
8F	−4.0	3.4	0	1.94	12	1.8	7.4
8G	+7.3	14.3	0	2.77	6.5	1.5	7.0
9	−5.6	2.9	0	1.99	12	2.0	8.5
10	+2.2	10.4	0	1.99	15	2.7	8.2
11	−22.4	6.7	9.8	1.99	27	4.5	19.3
12	−1.7	9.1	0	1.95	20	3.2	10.8
13	−6.2	1.5	0	1.95	9	1.5	7.7
14	−1.2	7.0	0	1.95	11	1.9	8.2
Total	−31.6	55.3	9.8	2.07	112	19.1	77.1
Stream-gaging station flow ... acre-feet							48.0
MAY							
8F	+6.8	17.8	0	3.27	13	3.4	11.0
8G	+127.7	155	0	3.44	31	5.7	26.9
9	+1.4	11.9	0	3.12	12	3.2	10.5
10	−.5	64.8	52.0	3.12	17	4.5	13.3
11	+14.3	36.6	0	3.12	28	7.3	22.3
12	+.8	41.9	29.0	3.46	21	6.1	12.1
13	+5.0	14.4	0	3.46	10	2.9	9.4
14	+9.4	49.2	31.8	3.46	14	3.5	8.0
Total	+164.9	392	113	3.31	146	36.6	114
Stream-gaging station flow ... acre-feet							615
JUNE							
8F	−9.1	2.0	0	0.45	12	0.5	11.1
8G	−27.5	.9	0	.13	28	.3	28.4
9	−13.3	1.2	0	.21	11	.2	14.5
10	−14.4	1.1	0	.21	15	.3	15.5
11	−33.9	2.2	7.0	.21	27	.5	29.1
12	−16.9	.7	0	.42	20	.7	17.6
13	−13.8	.6	0	.42	10	.4	14.4
14	−10.8	.7	0	.42	12	.4	11.5
Total	−139.7	9.4	7.0	0.31	135	3.3	142
Stream-gaging station flow ... acre-feet							0
JULY							
8F	−8.6	2.5	0	0.62	11	0.5	11.1
8G	−19.1	6.0	0	1.31	25	2.8	25.1
9	−10.4	2.4	0	.50	10	.3	12.8
10	−12.8	1.1	0	.50	12	.5	13.9
11	−44.2	1.6	20.0	.50	23	1.0	25.8
12	−16.8	.8	0	.50	19	.8	17.6
13	−9.9	.5	0	.50	9	.4	10.4
14	−11.2	.4	0	.50	10	.4	11.6
Total	−133.0	15.3	20.0	0.62	119	6.7	128
Stream-gaging station flow ... acre-feet							0

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
AUGUST							
8F	−7.7	3.3	0	0.45	9	0.3	11.0
8G	−20.2	3.8	0	.50	23	.9	24.0
9	−10.6	.6	0	.44	8	.2	11.2
10	−15.5	.4	0	.44	12	.4	15.9
11	−50.2	.8	27.0	.44	18	.7	24.0
12	−16.6	.7	0	.49	17	.7	17.3
13	−9.6	.4	0	.49	7	.3	10.0
14	−9.1	.8	0	.49	9	.4	9.9
Total	−139.5	10.8	27.0	0.47	103	3.9	123
Stream-gaging station flow……acre-feet							0
SEPTEMBER							
8F	−6.6	1.3	0	0.98	8	0.7	7.9
8G	−19.6	.1	0	.06	20	.1	19.7
9	−5.7	.2	0	.47	6	.2	5.9
10	−9.3	.4	0	.47	10	.4	9.7
11	−15.0	.6	0	.47	15	.6	15.6
12	−12.0	.4	0	.29	16	.4	12.4
13	−4.2	1.2	0	.29	6	.2	5.4
14	−6.6	.2	0	.29	8	.2	6.8
Total	−79.0	4.4	0	0.42	89	2.8	83.4
Stream-gaging station flow……acre-feet							0
Water year 1955–56 total	−228.2	941	198	14.71	107	133	970
							1,360
OCTOBER							
Controlled drainage area, 17.5 sq mi; all gaged							
8C [2]	+2.2	2.8	0	2.98	0.5	0.1	0.6
8F	−2.1	3.6	0	3.08	7.5	2.0	5.7
8G	−1.8	9.1	0	3.26	18	4.7	10.9
8H [2]	+2.0	3.0	0	2.98	1.0	.3	1.0
9	−2.3	1.6	0	2.91	5	1.1	3.9
10	−3.8	3.4	0	2.91	9	2.3	7.2
11	−4.9	3.4	0	2.91	14	3.4	8.3
12	−4.5	4.2	0	3.15	16	4.2	8.7
13	−3.3	1.4	0	3.15	5	1.3	4.7
14	−1.8	2.2	0	3.15	7	1.9	4.0
Total	−20.3	34.7	0	3.05	83	21.3	55.0
Uncontrolled drainage area, 21.5 sq mi							
Stream-gaging station flow……acre-feet							0

[2] Estimated on basis of record for adjacent sites.

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
NOVEMBER							
8C [2]	+3.2	6.6	0	3.72	1.5	0.5	3.4
8F	+.4	4.0	0	3.08	7.5	2.0	3.6
8G	+2.5	11.9	0	3.16	19	4.8	9.4
8H [2]	+3.0	7.0	0	3.72	1.5	.5	4.0
9	+.1	3.1	0	3.15	5	1.0	3.0
10	+.5	4.2	0	3.15	8	2.1	3.7
11	+6.9	14.0	0	3.15	15	3.9	7.1
12	+1.7	6.9	0	3.13	16	4.2	5.2
13	−.4	2.5	0	3.13	5	1.3	2.9
14	−.1	3.0	0	3.13	7	1.8	3.1
Total	+17.8	63.2	0	3.25	85.5	22.1	45.4
Stream-gaging station flow, acre-feet							56.0
DECEMBER							
8C [2]	+0.7	2.8	0	2.26	1	0.2	2.1
8F	+.8	3.5	0	2.02	7.5	1.2	2.7
8G	+1.6	9.3	0	2.15	17	3.2	7.7
8H [2]	0	3.0	0	2.26	1.5	.3	3.0
9	−.6	1.9	0	1.99	4	.8	2.5
10	+.1	3.0	0	1.99	9	1.4	2.9
11	−.3	5.4	0	1.99	14	2.3	5.7
12	+.2	4.2	0	2.11	15	2.6	4.0
13	−.8	1.5	0	2.11	5	.9	2.3
14	0	2.3	0	2.11	7	1.2	2.3
Total	+1.7	36.9	0	2.10	81	14.1	35.2
Stream-gaging station flow, acre-feet							0.8
1956 calendar year total	−76.2	1,050	193	21.69	105	179	932
							1,420
JANUARY 1957							
8C [2]	+1.4	4.0	0	2.27	1.5	0.3	2.6
8F	+1.3	3.4	0	2.48	7.5	1.4	2.1
8G	+3.5	10.2	0	2.20	18	3.3	6.7
8H [2]	0	5.0	0	2.27	1.5	.3	5.0
9	−.5	1.6	0	2.54	4	.9	2.1
10	+1.5	4.0	0	2.54	8	1.9	2.5
11	0	4.8	0	2.54	14	3.0	4.8
12	+.5	3.5	0	2.28	15	2.8	3.0
13	−.5	1.3	0	2.28	4	.8	1.8
14	+.2	2.1	0	2.28	7	1.3	1.9
Total	+7.4	39.9	0	2.37	80.5	16.0	32.5
Stream-gaging station flow, acre-feet							0

[2] Estimated on basis of record for adjacent sites.

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
			FEBRUARY				
8C [2]	+3.7	6.1	0	2.22	4	0.7	2.4
8F	+1.2	3.7	0	2.00	7.5	1.2	2.5
8G	+19.8	27.9	0	2.01	22	3.4	8.1
8H [2]	+4.0	8.0	0	2.22	3	.5	4.0
9	+.1	2.4	0	1.77	4	.6	2.3
10	+.2	3.0	0	1.77	10	1.5	2.8
11	+4.8	10.3	0	1.77	15	2.2	5.5
12	+3.4	6.9	0	2.05	16	2.7	3.5
13	+1.1	3.2	0	2.05	5	.8	2.1
14	+.8	2.9	0	2.05	7	1.3	2.1
Total	+39.1	74.4	0	1.99	93.5	14.9	35.3
Stream-gaging station flow						acre-feet	11.0
			MARCH				
8C	+96.2	108	0	6.47	12	5.9	12.2
8F	+49.2	52.9	0	5.88	9.5	5.0	3.7
8G	+287.7	374	73.0	5.60	30	15.5	13.2
8H	+118.0	129	0	6.47	5	3.0	11.0
9	+29.2	32.2	0	5.86	6	2.8	3.0
10	+44.0	47.9	0	5.86	11	5.5	3.9
11	+84.8	92.3	0	5.86	16	7.8	7.5
12	+29.2	34.0	0	5.44	16	7.2	4.8
13	+17.5	20.5	0	5.44	6	2.7	3.0
14	+8.3	11.1	0	5.44	8	3.5	2.8
Total	+764.1	902	73.0	5.83	120	58.9	65.1
Stream-gaging station flow						acre-feet	559
			APRIL				
8C	+649.6	1,180	516	14.46	50	80.6	14.6
8F	+350.8	598	238	13.19	28	37.4	9.7
8G	+960.7	2,081	1,085	13.97	70	107	34.7
8H	+687.2	1,245	547	14.46	30	66.5	11.2
9	+314.0	559	235	12.55	20	26.9	10.3
10	+384.0	800	407	12.55	28	35.0	8.4
11	+803.4	957	133	12.55	40	41.9	20.4
12	+448.8	684	226	14.05	28	32.8	9.2
13	+323.2	416	84.5	14.05	16	24.1	8.0
14	+185.0	462	272	14.05	16	24.8	5.0
Total	+5,106.7	8,982	3,744	13.59	326	477	132
Stream-gaging station flow						acre-feet	13,250
			MAY				
8C	−90.0	1,732	1,764	18.52	96	150	58.2
8F	+4.6	1,093	1,066	17.91	43	73.9	22.4
8G	−130.0	3,364	3,403	17.30	135	190	90.8
8H	−106.6	1,823	1,887	18.52	76	117	42.6
9	+65.0	1,145	1,055	17.94	34	57.5	24.7
10	−132.2	1,001	1,119	17.94	30	51.9	14.5
11	+209.5	1,605	1,340	17.94	87	129	55.6
12	−49.6	1,023	1,050	16.04	47	62.9	21.8
13	+51.9	561	484	16.04	30	40.2	24.8
14	+8.0	695	679	16.04	22	34.9	9.0
Total	−169.4	14,042	13,847	17.42	600	907	364
Stream-gaging station flow						acre-feet	26,680

[2] Estimated on basis of record for adjacent sites.

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
JUNE							
8C	−497.4	51.0	523	0.84	50	4.3	25.4
8F	−321.9	28.2	330	1.37	26	2.6	19.6
8G	−1,005.6	105	1,049	.78	74	5.6	61.2
8H	−475.2	34.9	486	.84	39	3.4	24.1
9	−313.0	18.8	313	.55	23	1.1	18.7
10	−233.7	12.2	235	.55	21	.9	10.9
11	−406.8	107	449	.55	78	3.6	64.4
12	−359.8	4.2	344	.89	30	2.2	20.0
13	−257.7	21.2	255	.89	25	1.9	23.9
14	−160.6	6.8	158	.89	16	1.2	9.1
Total	−4,031.7	389	4,142	0.82	382	26.8	277
Stream-gaging station flow ... acre-feet							3,440
JULY							
Controlled drainage area, 20.9 sq mi [gaged area, 17.5 sq mi]							
8C	−21.0	2.6	0	0.80	30	2.0	23.6
8F	−12.0	1.3	0	.04	18	.1	13.3
8G	−27.5	5.1	1.6	.71	38	2.1	31.0
8H	−18.7	1.7	0	.80	27	1.7	20.4
9	−15.3	.1	0	.04	16	.1	15.4
10	−14.5	.1	0	.04	16	.1	14.6
11	−356.8	42.7	352	.04	51	.2	47.5
12	−14.5	.2	0	.13	21	.2	14.7
13	−19.5	.2	0	.13	16	.2	19.7
14	−9.1	.1	0	.13	12	.1	9.2
Total	−508.9	54.1	354	0.29	245	6.8	209
Uncontrolled drainage area 18.1 sq mi							
Stream-gaging station flow ... acre-feet							395
AUGUST							
8C	−25.6	0.3	0	0.15	28	0.3	25.9
8F	−12.4	2.6	0	.15	17	.2	15.0
8G	−28.0	3.6	0	.13	33	.3	31.6
8H	−21.3	.3	0	.15	25	.3	21.6
9	−15.2	.3	0	.23	16	.3	15.5
10	−14.4	.3	0	.23	14	.3	14.7
11	−67.7	.8	24.9	.23	39	.7	43.6
12	−16.6	.8	0	.49	20	.8	17.4
13	−17.9	.6	0	.49	15	.6	18.5
14	−9.3	.5	0	.49	12	.5	9.8
Total	−228.4	10.1	24.9	0.27	219	4.3	214
Stream-gaging station flow ... acre-feet							1.8

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
SEPTEMBER							
8C	+17.4	34.7	0	5.52	27	12.0	17.3
8F	−1.0	8.4	0	4.61	17	6.6	9.4
8G	+7.4	27.3	0	6.17	30	14.6	19.9
8H	+2.1	14.1	0	5.52	25	11.0	12.0
9	−4.4	5.9	0	4.36	15	5.3	10.3
10	−1.4	4.8	0	4.36	13	4.7	6.2
11	−15.4	13.1	0	4.36	36	13.1	28.4
12	−1.1	7.6	0	4.80	19	7.6	8.7
13	−7.7	5.8	0	4.80	14	5.6	13.5
14	−.5	7.1	0	4.80	11	4.4	7.6
Total	−4.6	129	0	4.93	207	84.9	133
Stream-gaging station flow .... acre-feet							28.0
1956–57 water year total	+973.5	24,757	22,185	55.91	210	1,654	1,598
							44,430
OCTOBER							
Controlled drainage area, 20.9 sq mi; all gaged							
8C	−5.0	20.1	12.7	2.82	29	6.6	12.4
8D	+2.3	7.3	0	2.82	15	3.5	5.0
8E	+7.4	16.7	0	2.87	7	1.7	9.3
8F	−2.2	5.5	0	2.77	17	4.0	7.7
8G	−4.2	13.3	0	2.47	31	6.1	17.5
8H	−4.0	6.7	0	2.82	26	5.8	10.7
9	−4.3	3.3	0	2.88	14	3.3	7.6
10	−2.2	3.1	0	2.88	13	3.1	5.3
11	−8.4	13.2	0	2.88	35	8.4	21.6
12	−1.3	5.4	0	2.88	19	4.6	6.7
13	−8.6	3.8	0	2.88	13	3.3	12.4
14	−2.0	2.7	0	2.88	11	2.7	4.7
Total	−32.5	101	12.7	2.82	230	53.1	121
Stream-gaging station flow .... acre-feet							15.0
NOVEMBER							
8C	+45.6	293	238	7.40	38	22.9	9.0
8D	+117.1	127	0	7.40	20	12.5	9.9
8E	+153.6	166	0	7.42	22	10.0	12.0
8F	+29.7	163	129	7.53	20	12.1	4.4
8G	+61.9	584	506	6.94	48	28.7	16.2
8H	+44.7	228	176	7.40	29	17.5	7.8
9	+44.3	116	65.3	7.46	17	9.3	6.1
10	+35.2	134	94.7	7.46	17	9.5	3.6
11	+101.4	234	117	7.46	41	25.4	15.6
12	+36.8	151	108	8.10	22	14.9	6.2
13	+56.4	66.0	2.7	8.10	16	9.9	6.9
14	+24.6	133	106	8.10	15	10.0	2.8
Total	+751.3	2,395	1,543	7.56	305	183	100
Stream-gaging station flow .... acre-feet							2,870

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
DECEMBER							
8C	−1.5	23.1	16.6	1.68	30	4.2	8.0
8D	+10.9	66.9	47.0	1.68	27	3.8	9.0
8E	+9.5	61.0	43.9	1.80	28	4.1	7.6
8F	0	64.7	60.7	1.73	20	2.9	4.0
8G	−3.4	113	103	1.65	42	5.6	12.9
8H	+2.5	54.0	44.4	1.68	28	3.9	7.1
9	−1.2	51.8	47.2	1.74	17	2.5	5.8
10	−.3	42.5	39.3	1.74	17	2.2	3.5
11	−.8	96.0	83.0	1.74	42	6.1	13.8
12	−.4	50.3	47.0	1.92	22	3.5	3.7
13	+1.7	24.0	14.7	1.92	17	2.7	7.6
14	+.4	35.2	32.3	1.92	15	2.4	2.5
Total	+17.4	682	579	1.77	305	43.9	85.5
Stream-gaging station flow ... acre-feet							1,000
1957 calendar year total	+1,710.5	27,800	24,320	59.66	259	1,877	1,768
							48,260
JANUARY 1958							
8C	+12.8	74.9	54.5	2.21	34	6.2	7.6
8D	0	141	132	2.21	28	5.1	8.7
8E	+.5	99.2	90.0	1.96	28	4.5	8.7
8F	−.2	38.0	34.6	2.23	20	3.7	3.6
8G	+4.2	167	150	2.23	42	7.5	12.4
8H	+.3	91.2	84.0	2.21	29	5.1	6.9
9	+.5	73.5	67.5	2.06	17	2.9	5.5
10	0	56.5	53.2	2.06	17	3.1	3.3
11	0	144	131	2.06	42	7.2	13.0
12	+.6	67.8	64.0	2.04	22	3.7	3.2
13	−1.4	46.7	40.7	2.04	17	2.9	7.4
14	+.1	40.1	37.7	2.04	15	2.6	2.3
Total	+17.4	1,040	939	2.11	311	54.5	82.6
Stream-gaging station flow ... acre-feet							1,590
FEBRUARY							
8C	−9.8	23.8	25.1	0.93	30	2.3	8.5
8D	−.5	53.7	44.3	.93	26	2.1	9.9
8E	−1.1	33.7	24.7	.63	23	1.6	10.1
8F	−.6	17.5	13.5	.70	20	1.2	4.6
8G	−8.4	46.9	41.6	.69	41	2.3	13.7
8H	−.6	27.6	20.4	.93	28	2.2	7.8
9	−.2	18.7	12.6	.68	17	1.0	6.3
10	−.2	27.7	24.1	.68	17	1.0	3.8
11	−3.8	58.6	47.0	.68	42	2.4	15.4
12	−.9	33.2	30.0	.74	22	1.4	4.1
13	−1.8	8.5	2.1	.74	17	1.1	8.2
14	−.6	12.8	10.5	.74	15	1.0	2.9
Total	−28.5	363	296	0.76	303	19.6	95.3
Stream-gaging station flow ... acre feet							879

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
MARCH							
8C	+10.2	58.8	38.8	3.51	36	10.1	9.8
8D	+2.1	140	127	3.51	28	8.1	11.3
8E	0	91.2	79.4	3.46	28	8.0	11.8
8F	+1.8	53.0	45.8	3.57	20	5.9	5.4
8G	+21.2	179	142	3.55	42	12.4	15.7
8H	+1.2	82.5	72.5	3.51	28	8.1	8.8
9	+.2	85.2	78.0	3.73	17	5.2	7.0
10	+.8	71.3	66.1	3.73	17	5.2	4.4
11	+7.9	173	147	3.73	42	13.0	18.1
12	+1.7	86.2	79.0	4.26	22	7.8	5.5
13	+2.7	77.0	65.1	4.26	17	6.9	9.2
14	+.9	62.7	58.4	4.26	15	5.2	3.4
Total	+50.7	1,160	999	3.76	312	95.9	110
Stream-gaging station flow ... acre-feet							1,840
APRIL							
8C	+219.3	322	90.4	7.10	40	24.9	12.4
8D	+155.3	336	166	7.10	30	17.5	14.0
8E	+132.9	320	172	9.77	29	22.8	14.9
8F	+182.6	291	101	8.29	21	15.2	7.3
8G	+249.2	532	262	8.40	43	31.4	21.2
8H	+184.0	307	112	7.10	29	19.7	11.1
9	+123.0	232	100	8.68	18	13.7	8.8
10	+204.9	314	103	8.68	19	15.0	5.6
11	+299.5	442	120	8.68	43	31.1	22.5
12	+243.6	352	101	8.86	23	17.0	7.4
13	+78.7	162	72.6	8.86	18	13.5	11.1
14	+140.1	258	114	8.86	16	12.9	4.6
Total	+2,213.1	3,868	1,514	8.36	329	235	141
Stream-gaging station flow ... acre-feet							5,400
MAY							
8C	−233.4	205	422	3.21	40	17.2	16.7
8D	−165.2	228	373	3.21	33	13.0	20.0
8E	−141.8	305	425	1.34	32	4.6	21.6
8F	−185.5	295	465	2.96	34	10.0	15.3
8G	−274.4	683	917	1.44	64	9.6	40.3
8H	−189.6	204	378	3.21	35	13.5	16.1
9	−125.0	341	450	3.48	26	9.7	16.2
10	−206.9	316	510	3.48	27	11.2	12.9
11	−49.8	448	454	3.48	71	20.6	44.0
12	−246.2	173	395	3.68	34	10.4	24.2
13	−80.8	187	250	3.68	25	8.0	18.1
14	−141.3	292	424	3.68	23	8.0	9.0
Total	−2,039.9	3,677	5,463	3.07	444	136	254
Stream-gaging station flow ... acre-feet							9,250

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
JUNE							
8C	+0.9	36.0	15.4	2.72	33	7.3	19.7
8D	0	22.0	0	2.72	26	5.9	22.0
8E	−18.2	7.3	0	2.65	26	5.7	25.5
8F	−5.2	7.6	0	2.31	18	3.5	12.8
8G	+4.4	353	315	4.19	42	15.4	33.3
8H	−1.4	38.0	21.4	2.72	28	6.3	18.0
9	−8.1	5.8	0	2.29	17	3.3	13.9
10	−6.4	4.3	0	2.29	16	3.0	10.7
11	−263.4	33.6	256	2.29	47	9.0	41.0
12	−3.8	9.1	.2	2.34	21	4.1	12.7
13	−14.9	3.2	0	2.34	17	3.2	18.1
14	−5.4	3.1	0	2.34	13	2.4	8.5
Total	−321.5	523	608	2.60	304	69.1	236
Stream-gaging station flow......acre-feet							919
JULY							
8C	−27.9	6.0	0	1.42	30	3.6	33.9
8D	−22.4	5.5	0	1.42	26	3.1	27.9
8E	−28.8	3.2	0	1.17	23	2.3	32.0
8F	−14.6	2.2	0	1.33	18	2.0	16.8
8G	−31.0	17.5	9.4	1.46	39	4.8	39.1
8H	−28.0	4.6	0	1.42	27	3.2	32.6
9	−14.5	2.6	0	1.31	16	1.8	17.1
10	−27.1	1.6	15.0	1.31	14	1.6	13.7
11	−35.4	5.8	0	1.31	40	4.4	41.2
12	−13.2	2.5	0	1.44	21	2.5	15.7
13	−17.4	2.0	0	1.44	16	1.9	19.4
14	−9.3	1.5	0	1.44	12	1.4	10.8
Total	−269.6	55.0	24.4	1.37	282	32.6	300
Stream-gaging station flow......acre-feet							18.0
AUGUST							
8C	−20.4	5.0	0	1.56	28	3.7	25.4
8D	−11.9	7.8	0	1.56	26	3.4	19.7
8E	−13.4	6.3	0	1.31	21	2.4	19.7
8F	−8.7	4.3	0	2.02	17	2.9	13.0
8G	−29.7	6.2	0	1.88	30	4.9	35.9
8H	−17.9	4.4	0	1.56	25	3.4	22.3
9	−12.1	3.8	0	1.97	15	2.5	15.9
10	−11.7	2.0	3.0	1.97	12	2.0	10.7
11	−28.2	6.6	0	1.97	38	6.2	34.8
12	−11.6	2.6	0	1.18	20	2.0	14.2
13	−17.7	1.8	0	1.18	14	1.3	19.5
14	−5.6	2.1	0	1.18	11	1.2	7.7
Total	−188.9	52.9	3.0	1.61	257	35.9	239
Stream-gaging station flow......acre-feet							0

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
SEPTEMBER							
8C	−6.1	14.0	0	2.35	27	5.0	20.1
8D	−11.7	8.4	0	2.35	26	5.0	20.1
8E	−8.0	12.9	0	3.39	20	5.8	20.9
8F	−1.3	11.7	0	3.80	16	5.0	13.0
8G	−13.9	12.7	0	2.27	27	5.1	26.6
8H	−3.6	12.3	0	2.35	24	4.7	15.9
9	−6.9	11.0	4.0	3.36	14	3.9	13.9
10	−2.9	7.2	0	3.36	12	3.4	10.1
11	−15.2	14.4	0	3.36	36	10.1	29.6
12	−4.8	7.1	0	4.50	19	7.1	11.9
13	−8.2	6.4	0	4.50	13	4.9	14.6
14	+3.2	12.8	0	4.50	11	4.4	9.6
Total	−79.4	131	4.0	3.34	245	64.4	206
Stream-gaging station flow acre-feet							42.0
1957–58 water year total	+89.6	14,048	11,985	39.13	302	1,023	1,970
							23,820
OCTOBER							
8C	−26.3	3.5	12.0	0.98	24	2.0	17.8
8D	−11.0	2.6	0	.98	24	1.9	13.6
8E	−6.1	4.2	0	.69	18	1.1	10.3
8F	−6.4	1.5	0	.82	15	1.0	7.9
8G	−23.4	3.0	0	1.08	26	2.3	26.4
8H	−11.2	1.8	0	.98	22	1.8	13.0
9	−7.9	.9	0	.87	13	.9	8.8
10	−3.7	.9	0	.87	12	.8	4.6
11	−16.4	2.6	0	.87	36	2.6	19.0
12	−4.0	2.4	0	1.49	14	1.7	6.4
13	−8.4	1.5	0	1.49	12	1.5	9.9
14	−3.3	1.4	0	1.49	11	1.4	4.7
Total	−128.1	26.3	12.0	1.05	227	19.0	142
Stream-gaging station flow acre-feet							0
NOVEMBER							
8C	+0.5	13.4	0	2.78	24	5.6	12.9
8D	−1.1	6.9	0	2.78	23	5.4	8.0
8E	−2.3	7.8	0	2.40	18	3.6	10.1
8F	+.8	5.9	0	2.41	14	2.9	5.1
8G	+2.0	14.4	0	3.37	25	7.0	12.4
8H	−1.1	6.9	0	2.78	21	4.9	8.0
9	−2.8	4.1	0	2.44	12	2.5	6.9
10	−.2	3.5	0	2.44	11	2.2	3.7
11	−7.3	9.1	0	2.44	35	7.1	16.4
12	−1.4	3.8	0	2.31	14	2.7	5.2
13	−3.1	3.8	0	2.31	11	2.1	6.9
14	−1.1	3.8	0	2.31	11	2.1	4.9
Total	−17.1	83.4	0	2.56	219	48.1	100
Stream-gaging station flow acre-feet							20.0

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
DECEMBER							
8C	−5.1	1.5	0	0.69	24	1.4	6.6
8D	−3.3	3.3	0	.69	23	1.4	6.6
8E	−4.7	2.3	0	.73	18	1.1	7.0
8F	−3.8	.8	0	.72	14	.8	4.6
8G	−6.0	2.8	0	.74	25	1.5	8.8
8H	−4.0	2.3	0	.69	21	1.2	6.3
9	−4.0	1.0	0	.74	12	.8	5.0
10	−2.0	1.0	0	.74	11	.7	3.0
11	−8.3	4.8	0	.74	35	2.2	13.1
12	−1.8	1.7	0	.81	14	.9	3.5
13	−6.6	.8	0	.81	11	.7	7.4
14	−1.3	1.4	0	.81	11	.7	2.7
Total	−50.9	23.7	0	0.74	219	13.4	74.6
Stream-gaging station flow ..... acre-feet							70.0
1958 calendar year total	−842.7	11,003	9,862	31.33	288	824	1,980
							20,030
JANUARY 1959							
8C	−1.8	4.6	0	0.33	23	0.7	6.4
8D	−1.3	5.1	0	.33	23	.6	6.4
8E	−3.3	3.1	0	.23	17	.3	6.4
8F	−.3	3.2	0	.17	14	.2	3.5
8G	−1.9	6.6	0	.32	24	.6	8.5
8H	−1.4	4.6	0	.33	20	.6	6.0
9	−4.1	.1	0	.15	11	.1	4.2
10	−1.4	1.4	0	.15	11	.1	2.8
11	−8.0	4.5	0	.15	34	.4	12.5
12	−2.4	1.2	0	.16	14	.2	3.6
13	−4.4	.7	0	.16	10	.1	5.1
14	−2.0	.5	0	.16	11	.1	2.5
Total	−32.3	35.6	0	0.22	212	4.0	67.9
Stream-gaging station flow ..... acre-feet							59.0
FEBRUARY							
8C	0	6.4	0	1.34	24	2.6	6.4
8D	−1.4	4.9	0	1.34	22	2.6	6.3
8E	−.9	5.5	0	1.45	16	1.9	6.4
8F	−.5	3.0	0	1.27	14	1.5	3.5
8G	−1.7	6.7	0	1.40	24	2.8	8.4
8H	−.6	5.5	0	1.34	20	2.2	6.1
9	−1.6	2.2	0	1.29	11	1.2	3.8
10	−.6	2.2	0	1.29	11	1.3	2.8
11	−4.2	8.1	0	1.29	34	3.7	12.3
12	−.5	2.8	0	1.31	13	1.4	3.3
13	−3.8	1.2	0	1.31	10	1.1	5.0
14	−.4	2.2	0	1.31	11	1.2	2.6
Total	−16.2	50.7	0	1.33	210	23.5	66.9
Stream-gaging station flow ..... acre-feet							65.0

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
MARCH							
8C	+4.7	16.3	0	2.45	23	4.8	11.6
8D	−3.5	7.6	0	2.45	22	4.6	11.1
8E	−2.6	9.6	0	2.58	16	3.4	12.2
8F	+1.2	9.3	0	3.27	14	3.8	8.1
8G	−6.0	8.2	0	2.18	24	4.4	14.2
8H	−2.4	8.4	0	2.45	19	3.9	10.8
9	−2.7	3.9	0	2.56	11	2.2	6.6
10	+11.9	17.8	0	2.56	12	2.5	5.9
11	−6.3	16.6	0	2.56	33	7.0	22.9
12	+1.0	9.0	0	2.49	13	2.7	8.0
13	−3.1	5.2	0	2.49	10	2.1	8.3
14	+.4	6.1	0	2.49	10	2.1	5.7
Total	−7.4	118	0	2.54	207	43.5	125
Stream-gaging station flow ... acre-feet							86.0
APRIL							
8C	−7.8	4.2	0	0.69	23	1.3	12.0
8D	−6.6	5.8	0	.69	22	1.2	12.4
8E	−6.4	6.4	0	.92	16	1.1	12.8
8F	−3.9	4.3	0	.80	14	.9	8.2
8G	−11.6	2.8	0	.67	22	1.2	14.4
8H	−6.5	4.5	0	.69	18	1.1	11.0
9	−4.0	2.8	0	.87	10	.7	6.8
10	−2.2	3.9	0	.87	12	.8	6.1
11	−12.6	10.4	0	.87	32	2.3	23.0
12	−3.2	5.5	0	.97	13	1.0	8.7
13	−5.5	2.5	0	.97	10	.8	8.0
14	−3.7	2.1	0	.97	10	.8	5.8
Total	−74.0	55.2	0	0.83	202	13.2	129
Stream-gaging station flow ... acre-feet							98.0
MAY							
8C	−7.5	7.3	0	2.13	22	3.9	14.8
8D	−6.4	7.1	0	2.13	22	3.9	13.5
8E	−4.7	10.5	0	2.74	16	3.6	15.2
8F	−3.1	7.3	0	3.11	13	3.4	10.4
8G	−9.2	8.1	0	2.42	21	4.3	17.3
8H	−5.4	8.0	0	2.13	18	3.2	13.4
9	−2.6	5.5	0	3.10	10	2.5	8.1
10	−.6	7.3	0	3.10	12	3.2	7.9
11	−8.7	19.6	0	3.10	31	8.0	28.3
12	−.3	11.1	0	2.50	13	2.7	11.4
13	−4.2	5.2	0	2.50	10	2.5	9.4
14	+2.2	9.8	0	2.50	10	2.5	7.6
Total	−50.5	107	0	2.62	198	43.7	157
Stream-gaging station flow ... acre-feet							31.0

TABLE 14.—*Suface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
JUNE							
8C	+60.0	76.3	0	7.14	23	13.6	16.3
8D	+34.1	50.5	0	7.14	23	13.7	16.4
8E	+25.1	40.9	0	7.40	16	9.5	15.8
8F	+31.9	42.8	0	6.52	14	7.4	10.9
8G	+80.7	104	0	7.23	25	13.7	23.1
8H	+39.1	53.4	0	7.14	20	11.7	14.3
9	+7.2	15.6	0	7.11	10	6.0	8.4
10	+15.5	23.7	0	7.11	12	7.1	8.2
11	+8.7	38.0	0	7.11	31	18.4	29.3
12	+5.0	16.5	0	5.54	13	6.0	11.5
13	+2.0	11.8	0	5.54	10	4.6	9.8
14	+.6	7.3	0	5.54	10	4.8	6.7
Total	+309.9	481	0	6.71	207	116	171
Stream-gaging station flow						acre-feet	343
JULY							
8C	+21.2	71.4	28.0	5.43	29	13.1	22.2
8D	+48.1	69.4	1.1	5.43	26	11.4	20.2
8E	+12.7	30.7	0	5.17	19	8.1	18.0
8F	−1.9	17.7	7.0	3.98	18	5.8	12.6
8G	+57.6	386	294	7.23	42	24.1	33.9
8H	+41.0	71.0	5.0	5.43	28	12.4	25.0
9	+.4	9.1	0	4.75	10	3.9	8.7
10	−3.6	6.6	0	4.75	12	4.9	10.2
11	+6.9	34.8	0	4.75	31	12.3	27.9
12	+3.7	14.8	0	4.76	14	5.6	11.1
13	+1.8	11.3	0	4.76	10	4.0	9.5
14	−.2	6.5	0	4.76	10	4.2	6.7
Total	+187.7	729	335	5.10	249	110	206
Stream-gaging station flow						acre-feet	838
AUGUST							
8C	−20.0	5.2	0	2.04	28	4.8	25.2
8D	−11.2	11.3	0	2.04	26	4.4	22.5
8E	−11.2	8.4	0	1.68	19	2.6	19.6
8F	−8.8	5.3	0	2.44	17	3.4	14.1
8G	−33.3	9.8	8.1	1.86	38	5.5	35.0
8H	−19.0	4.4	0	2.04	27	4.4	23.4
9	−9.0	1.7	0	2.10	10	1.7	10.7
10	−8.5	2.7	0	2.10	12	2.1	11.2
11	−20.7	8.9	0	2.10	31	5.4	29.6
12	−6.0	6.2	0	4.15	14	4.8	12.2
13	−7.2	3.1	0	4.15	9	3.1	10.3
14	−1.8	5.9	0	4.15	10	3.4	7.7
Total	−156.7	72.9	8.1	2.57	241	45.6	222
Stream-gaging station flow						acre-feet	0.2

TABLE 14.—*Surface-water budget summary for gaged watersheds of Honey Creek basin, water years 1953–59*—Continued

[Rainfall at rain gage nearest to site (see fig. 4)]

Site	Change in contents (acre-feet)	Total inflow (acre-feet)	Total discharge through outlets (acre-feet)	Rainfall (in.)	Average surface area (acres)	Rainfall on pool area (acre-feet)	Pool consumption (acre-feet)
SEPTEMBER							
8C	−24.4	1.7	0	0.80	26	1.7	26.1
8D	−19.0	2.1	0	.80	26	1.7	21.1
8E	−10.5	5.2	0	.87	17	1.2	15.7
8F	−8.5	2.1	0	.93	16	1.1	10.6
8G	−23.1	2.3	0	.74	33	1.9	25.4
8H	−13.0	3.1	0	.80	26	1.7	16.1
9	−7.3	1.6	0	.82	10	.6	8.9
10	−6.7	1.9	0	.82	12	.8	8.6
11	−19.9	4.6	0	.82	29	2.0	24.5
12	−7.8	2.6	0	.80	13	.9	10.4
13	−7.2	.8	0	.80	9	.6	8.0
14	−6.0	.9	0	.80	10	.7	6.9
Total	−153.4	28.9	0	0.82	227	14.9	182
Stream-gaging station flow ... acre-feet							0
1958–59 water year total	−189.0	1,812	355	27.09	218	495	1,643
							1,610

The effects on runoff immediately below the dam at each site are more or less apparent from the water-budget analyses. The average annual inflow to the gaged pools during the 7-year period of study was 7.39 inches, of which 0.73 inch was direct rainfall on the pool surface. The average annual pool consumption due to evaporation, seepage, transpiration, and other minor depletions was the equivalent of 1.62 inches of runoff for this same period. Therefore, about 22 percent of the average annual inflow to the pools, including rainfall on the pool surface, was consumed or diverted to ground-water storage. The relation between pool inflow and consumption on an annual basis was as follows:

Water year	Number of pools	Drainage area (sq. mi.) above structures	Inflow		Consumption		Percent consumed or diverted
			Acre-feet	Inches	Acre-feet	Inches	
1953	2	3.40	546	3.01	242	1.33	44
1954	2	3.40	606	3.34	336	1.85	55
1955	6	7.82	1,392	3.34	771	1.85	55
1956	8	13.2	941	1.34	970	1.38	103
1957	10	17.5	24,757	26.50	1,598	1.71	6
1958	12	20.9	14,048	12.60	1,970	1.77	14
1959	12	20.9	1,812	1.63	1,643	1.47	91

Annual runoff during the 7-year period varied through a wide range—from 1.34 to 26.50 inches; however, except for 1957 the annual amounts are below the average for the period 1903–53 as appraised on the basis of rainfall. Therefore, the percent consumed or diverted to ground-water storage must also reflect values above the average for the longer period. In contrast to variability of runoff, the amount consumed or diverted was relatively constant, varying only through the range from 1.33 to 1.85 inches.

The average annual surface runoff past the gaging station at the lower end of the basin was 5.91 inches during the 7-year period. Separation of this runoff into the component parts of outflow from the structures and runoff from the area below the structures was not made. However, table 14 shows that for the month of June 1957, the structures discharged a total of 4,142 acre-feet while the flow past the stream-gaging station was only 3,440 acre-feet. This indicates a transmission loss for this month of 702 acre-feet, plus any inflow from the 21.5-square-mile uncontrolled area below the structures. There are approximately 17 miles of stream channels below the structures, and the average surface area of the flowing water in the channels was approximately 50 acres. At most, about 50 acre-feet of this loss could attributed to evaporation. The remaining loss is attributed to channel seepage and to transpiration by the many trees which line the banks of the channels. Table 14 shows no large transmission loss in any other month. For 14 months of the 7-year period some flow passed one or more structures although none was recorded at the downstream gage. Of these the largest amount was 36 acre-feet in August 1955, which passed either site 10 or 11 and was lost in transit before reaching the lower gage.

From the examples cited it is evident that substantial depletion of flow by transmission losses can and does occur. Data do not exist to fully evaluate transmission losses, thus the extent to which losses at pools alter the flow at some downstream point is not known. Apparently, downstream effects would exist, but their magnitude would be less than those shown at the upstream structures. If overbank flooding is reduced or eliminated by controlling the rates of flood flow, some seepage losses, which exist under natural conditions, should be reduced. Thus it appears that the alteration of the flow pattern and the distribution of flow caused by floodwater-retarding structures should decrease flow at times and increase it at other times. As investigations such as this one continue, additional information on this aspect of the investigation will be obtained.

Data collected thus far indicate that in years of substantial runoff the effect of structures on downstream water yield will be minor. The data also indicate that during a year of low runoff the effect would be substantial and in a very dry year sufficient to hold most runoff above the structures.

EFFECTS ON FLOODS

Floodwater-retarding structures on watersheds of a stream basin have a marked effect on the flow regimens immediately downstream from the structures. Figure 20 shows representative inflow and outflow hydrographs for site 11. The peak inflow was 1,880 cfs, but the maximum outflow was only 7.6 cfs. However, the outflow continued for four weeks after the inflow had stopped.

The effect on the flood regimen at a downstream point produced by floodwater-retarding structures in the headwaters will vary with the amount and intensity of the precipitation and with antecedent conditions. The beneficial effects of the structures on Honey Creek during the floods of April and May 1957 is illustrative. During the period April 19 to May 31, 1957, the total volume of inflow to the floodwater-retarding structures was equivalent to 4.3 times the combined capacities of the pools (see table 1). The average basin rainfall during this period was 30.31 inches, distributed as shown in table 2. The retarding effects of the structures limited the flooding on Honey Creek at the gage to minor flooding on only five occasions during that period.

The lengthening of the period during which flow occurs immediately below the structures because of the draining of stored water has two implications. It may require modification of flood-control operations downstream, and it may affect the physical characteristics of the channels below the structures.

As more and more floodwater-retarding structures are built on watersheds tributary to major streams below large flood-control dams, it is foreseeable that the efficient operation of these large reservoirs will depend on adequate knowledge of the outflow from smaller floodwater-retarding structures. Table 1 shows that the average time required to empty the full floodwater-retarding pools at the 12 sites investigated was 24 days at the average rate of about 140 cfs. The pools were not full during this outflow period. If these data were applied to a much larger area than the 39.0 square mile basin of study, some adjustment in the operation of a flood-control reservoir located upstream from the tributary area might be necessary in order not to flood the channel downstream.

The increase in the duration of flow after floods could cause changes in channel geometry downstream. The relatively silt-free water being discharged from the structures would be expected to modify the natural streambed. There is also the prospect of additional and more

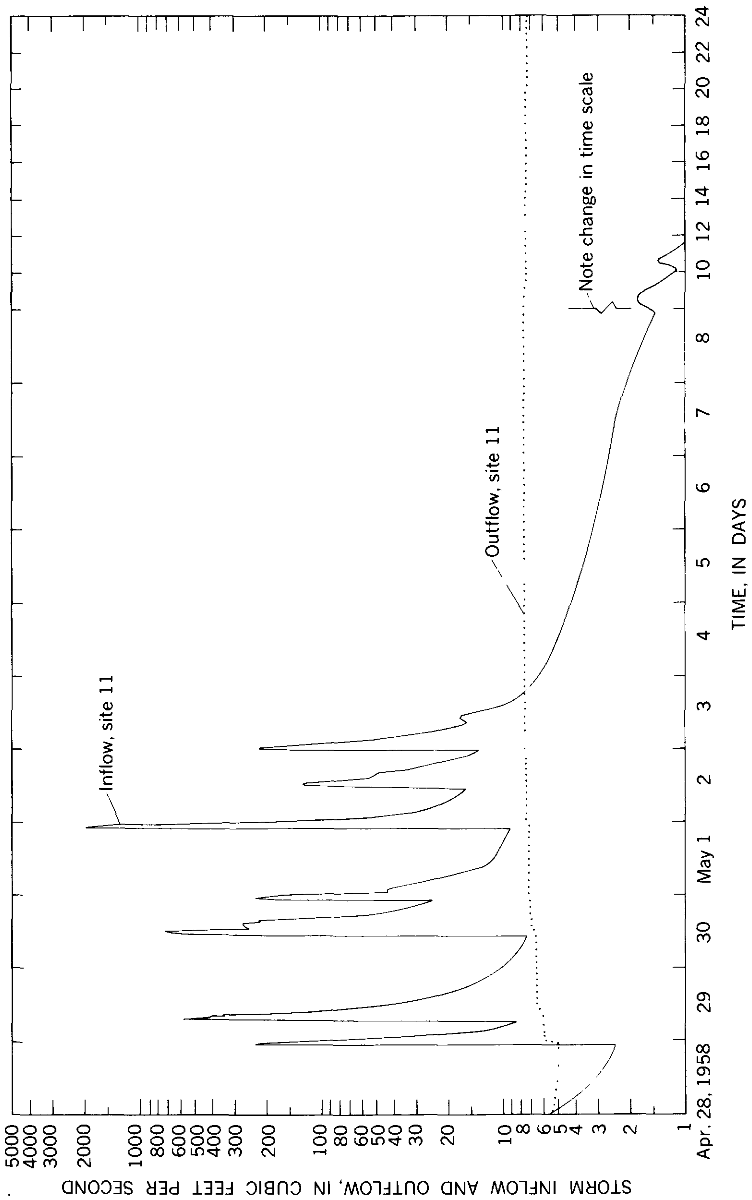

FIGURE 20.—Inflow and outflow hydrograph for site 11, April 28 to May 24, 1958.

prolific vegetal growth in and along the channels due to this abundance of streamflow for long periods. In the absence of scouring floods, this vegetation would reduce channel capacities and remain to transpire more of the outflow. Continued investigation in this and similar watersheds to define these changes in flow regimen is intended.

SUMMARY AND CONCLUSIONS

Annual runoff into the floodwater-retarding pools ranged from 1.34 inches depth on the drainage area in 1956 to 26.50 inches in 1957. Pool consumption varied from and was equivalent to 1.33 inches of runoff in 1953 to 1.85 inches in 1954 and 1955. In relation to inflow, pool consumption ranged from 103 percent in 1956 to 6 percent in 1957 and averaged 22 percent for the 7-year period.

Results indicate that the annual yield of the basin is not appreciably reduced because of the floodwater-retarding pools during years of high runoff. However, during years of low runoff, the area controlled by the pools would be practically noncontributing.

Floodwater-retarding pools contained all flood flows except during the period April 19 to May 31, 1957, when 30 inches of rain fell. The inflow to the pools during this period of high runoff was 4.3 times the combined capacity of the pools, yet minor flooding was experienced on Honey Creek on only five occasions.

One effect of the pools on the flow regimen below the pools and for a considerable distance downstream was to reduce the flood peak and to prolong the flow for about 2 to 5 weeks following the peak. The changes in channel capacity and character which may result because of this change in regimen cannot be evaluated at this time.

Results of the analyses indicate the following with respect to adequacy of the information collected during the investigation:

1. The rain-gage network of one gage per floodwater-retarding site was adequate in this area both for defining the rainfall on the watershed and for defining the mean watershed rainfall. Fewer gages would have provided a satisfactory estimate of mean watershed rainfall.
2. Measurements which would permit computation of evaporation by the mass-transfer method should have been available throughout the investigation.
3. The recording pool gages permitted the computation of reasonably reliable inflow rates to the pool.
4. More complete information would have been desirable for defining inflow to those pools served only by a nonrecording gage. Peak-stage indicators installed at all pools during the latter part of the investigation provided useful supplementary information. Pe-

riodic observations of outflow and base inflow were found valuable.

5. Records of unregulated flow on a physically comparable basin close to Honey Creek would have permitted more definite conclusions as to the effects of the floodwater-retarding pools on downstream yields and on flood-peak reduction. The analysis did not permit an adequate evaluation of the effects of floodwater-retarding structures on water yield at downstream points.

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