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PROGRESS REPORT

HYDROLOGIC STUDY OF INTERMEDIATE SIZE WATERSHEDS IN IOWA

Merwin D. Dougal

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July 1, 1968

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HYDROLOGIC STUDY OF INTERMEDIATE SIZE WATERSHEDS IN IOWA

INTRODUCTION

The Iowa Natural Resources Council in 1952 and 1953 assisted in the establishment of hydrologic networks in four intermediate-size watersheds in Iowa. These were:

- Paint Creek, Allamakee County, drainage area at stream gaging station near Waterville, 42.8 sq mi.
- East Fork Hardin Creek, Greene County, drainage area at stream gaging station near Churdan, 24.0 sq mi.
- David's Creek, Audubon County, drainage area at stream gaging station near Hamlin, 26.0 sq mi.
- Honey Creek, Lucas County, drainage area at stream gaging station near Russell, 13.2 sq mi.

The purpose of establishing these four networks was to obtain needed hydrologic information for watersheds greater than 10 sq mi but less than 50 sq mi. Little if any precipitation and runoff information is available for Iowa streams in this intermediate size category. The four areas selected were representative of the various physiographic areas existing in Iowa.

Stream gaging stations for each watershed were installed and have since been maintained by the Geological Survey, US Department of Interior, through the district office located at Iowa City, Iowa, and in cooperation with the Iowa Geological Survey. The stream flow records have been published annually in the USGS Water Supply Papers, and periodically a summary of all Iowa stream flow records has been published by the Iowa Geological Survey in cooperation with the US Geological Survey[1-3].

A sediment station has also been maintained at the Honey Creek gaging station. However, this station has now been abandoned because of construction of Rathbun Dam, on the Chariton River near Centerville, Iowa. The Iowa Natural Resources Council* established a recording precipitation gage in each watershed. A volunteer observer was located in each watershed to operate the precipitation gage, and all records were returned to the state climatologist at Des Moines.

The precipitation gage network has been maintained continuously and consistently at only one location: Paint Creek Watershed in Allamakee County. At this station, an excellent record has been obtained from June 1953 to date. Because of the heavy work load imposed upon the staff at the Natural Resources Council by the developing water resources responsibilities within the state, little attention could be given to the collection and analysis of the records. Intermittent operation of the remaining three precipitation gages resulted, and operation of the network was terminated by 1962, except for the Paint Creek station.

During the period 1962-1966 and through informal arrangements between the Iowa Natural Resources Council and Engineering Research Institute, operation of the network was gradually reinstated, and data analysis was initiated. The current research project began in 1966, for a three-year period. The project goals, at the time the contract was initiated, included:

- Continuing the analysis of precipitation gage records for the established stations in the Paint Creek and East Fork Hardin Creek Watersheds, with part-time civil engineering student assistance.

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*In cooperation with the Weather Bureau, Environmental Sciences Service Administration, US Department of Commerce, (State Climatologist, Federal Building, Des Moines, Iowa).

- Assisting the Iowa Natural Resources Council and the Weather Bureau in placing the David's Creek precipitation gage back in service and relocating the Honey Creek precipitation gage in a new watershed to obtain hydrologic data in similar watersheds, and thereafter analyzing precipitation records of these re-established stations as in the preceding step.
- Evaluating and reporting on the adequacy of the hydrologic network and any changes or expansions which might be desirable.
- Completing a comprehensive hydrologic study of the Paint Creek watershed during the 1968-69 academic year and publishing a report in 1969. The year 1967 completed 15 calendar years of operation.

STATUS OF PRECIPITATION DATA COLLECTION

Precipitation records for Paint Creek watershed are continuous since 1953. The precipitation gage for East Fork Hardin Creek was reactivated at its last existing location in August 1963, and a continuous record has since been obtained. The precipitation gage for David's Creek was relocated in August 1966 with a new observer, and an excellent record since that time has been obtained. A second gage was installed in the Paint Creek watershed in 1967 as is explained in a later section. Data concerning location and observers are tabulated in Table 1. An aerial mosaic of the Paint Creek watershed is shown in Fig. 1, and the locations of the various watersheds considered for hydrologic instrumentation are shown in Fig. 2.

Table 1. Recording precipitation gages — intermediate size watershed study, 1953-1968.

Date installed	Observer	Location
Paint Creek, station 1, near Waterville and Waukon, Iowa, 42.8 sq mi:		
May 1953	Barthell Bakkum	SE¼ Sec 11-97-5, Jefferson Twp., Allamakee County
Apr 1955	William Wild	SW¼ Sec 6-97-4 about 6 mi E of Waukon, Route #2, Waukon
Aug 1957 to date	Walter Hagen	7.9 mi SE of Waukon, SE¼ Sec 19-97-4 Paint Creek Twp., Allamakee County. Address: Waterville, Iowa
Paint Creek, station 2, near Waukon, Iowa, 42.8 sq mi (precipitation gage transferred from Honey Creek):		
Aug 1967	Mrs. Edna Smedsrud	8 mi E of Waukon, in Sec 33-98-4.
July 1968 to date	Mr. Richard Hagen	8 mi E of Waukon, in SE¼ Sec 33-98-4 Address: Waterville, Iowa
East Fork Hardin Creek, near Churdan and Jefferson, Iowa, 24.0 sq mi:		
May 1953	Louis D. Tronchetti	SE¼ Sec 29-89-30, Dawson Twp., Greene Co.
Jan 1954	Edwin Fisher	NW¼ Sec 29-85-30 about 9.5 mi N of Jefferson
Nov 1954	Lawrence Nahnsen	SE¼ Sec 8-85-30
Apr 1959 to date	Mrs. Daisy Zwicky	NW corner, SW¼ Sec 29-85-30 on Iowa #17 about 9 mi N of Jefferson Address: Jefferson, Iowa
David's Creek near Hamlin, Iowa, 26.0 sq mi:		
May 1953	Everett Black	SW¼ Sec 24-80-34, Melville Twp., Audubon Co.
Jan 1954	Carl Carlson	SW¼ Sec 25-80-34, gage located across road in NW¼ Sec 36-80-34, 9 mi E, 1 mi S of Audubon
Mar 1955	Glenn Johnson	NW¼ Sec 12-80-34, Route #2, Coon Rapids

Table 1. Continued.

Date installed	Observer	Location
Mar 1955	Leonard Ditto	8½ mi ENE of Audubon, NE¼ Sec 14-80-34, Melville Twp., Audubon Co.
Aug 1966 to date	Mrs. Richard Sandage	9 mi E of Audubon, Iowa, near N¼ corner, Sec 25-80-34, Melville Twp., Audubon Co. Address: Audubon, Iowa

Figure 1. Aerial Mosaic of Paint Creek Watershed
Allamakee County , Iowa

Uncontrolled mosaic compiled from USDA
1:20,000 aerial photographs, series SP-1957.

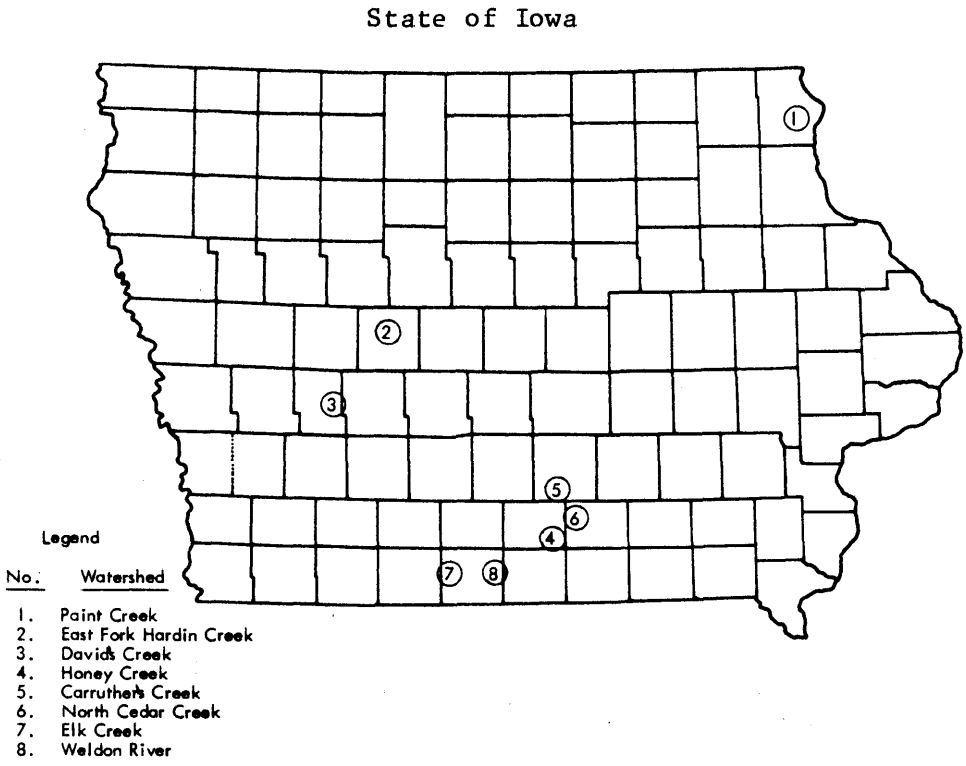

Fig. 2. Location of watersheds considered for hydrologic studies.

STUDY OF NEW HYDROLOGIC NETWORKS IN SOUTHERN AND NORTHERN IOWA

Discontinuance of Honey Creek Network

The precipitation gage previously located in the Honey Creek watershed was removed in August 1966. The stream gaging station maintained by the US Geological Survey was discontinued by September 1962. This watershed was included in a pilot watershed protection program of the US Department of Agriculture, beginning in 1954. In addition to the gage installed by the Iowa Natural Resources Council, two additional precipitation gages were installed and maintained by the Soil Conservation Service and the US Weather Bureau during the period 1956-1962.

A thorough evaluation of the pilot watershed protection program has been reported in a recent publication[4] by the US Department of Agriculture. This includes hydrologic and geologic studies.

Study of Three Southern Iowa Watersheds and Hydrologic Network Needs

Following the discontinuance of the Honey Creek hydrologic network, the need for instrumenting and collecting hydrologic data from a southern Iowa watershed has been discussed frequently. This area is within the Iowa-Missouri "Heavy Till Plain Land Resource Area," as identified by the Soil Conservation Service, USDA, and includes southern and southeastern Iowa counties. Representatives of the US Weather Bureau (ESSA), the US Geological Survey, Iowa Geological Survey, Iowa Natural Resources Council, Engineering Research Institute of Iowa State University, and other agencies have been involved in these periodic discussions. The most favorable location not too distant from the Honey Creek watershed was determined to be within the Cedar Creek basin, in the Lucas-Monroe-Marion County area.

One stream gaging station is presently located on the stream, near Bussey, with a drainage area of 374 sq mi. Within the context of this report, the terms watershed and drainage basin are synonomous, with the added implication that watersheds are the tributary "sub-basins" within larger drainage basins.

Two watersheds within the Cedar Creek basin were selected in 1967 for additional field investigations. They are located within 20 mi north-northwest of the Honey Creek watershed. These were:

- North Cedar Creek. Drainage area at east Lucas County line, Sec 13-73-20, 43.2 sq mi.
- Carruther's Creek. Drainage area at confluence with North Cedar Creek, Sec 33-74-19, 43.2 sq mi.

The proposed installation by the Weather Bureau of a telemetering rain gage station near Columbia, favored the Carruther's Creek watershed for selection. However, at this same time, the US Geological Survey discussed the implementation of a series of "bench mark" basins in the United States. These would be drainage basins in which future, man-made changes in physiography and land use were expected to be minimized or excluded. In Iowa, the USGS had tentatively selected the Elk Creek watershed in southern Iowa, Decatur County. A tributary of the Thompson River, it has a drainage area of 66 sq mi, of which only 50 to 52 sq mi would be gaged. One nonrecording precipitation gage in the present climatological network near this watershed is the Beaconsfield station. Another would be added, by the US Weather Bureau, EESA in cooperation with the USGS. Therefore, all three watersheds were included in the field inspections to determine general physiographic differences.

Field inspections of the three watersheds were made in the summer of 1967. This was followed by a review of the county and state soil reports for the counties in which the three watersheds are located.

The soil series classifications have changed considerably since the county soil maps were first issued during the period 1932-1935. The 1965 report[5] gives new classifications for all areas in Iowa, but is not as detailed for small areas as the former county maps. Two major soil association areas are identified in the study areas: (1) the Lindley-Keswick-Keller and (2) the Adair-Grundy-Haig soil series. Both of these soil association areas have the same geological history. The two areas are also adjacent to each other in this southern Iowa region. The steeper topography and more narrow upland ridges are characteristic of the first area. The Elk Creek watershed is primarily in the latter category. The other two watersheds, both in the larger Cedar Creek basin, are a mixture of the two series. The soils of the Lindley-Keswick-Keller series presumably were formed from forest cover, with loess over the lower till. In addition, shale outcropping may have influenced the soil profile development. Soils in the Adair-Grundy-Haig series were derived mostly from the prairie grass on loess and glacial till with little influence by forest cover. In the southwestern portion of the Cedar Creek basin, forest cover on the slopes apparently influenced the formation of the soils of the Lindley-Keswick-Keller series, but the flat uplands were of prairie origin or Grundy-Haig. The Elk Creek area is in the latter category.

Topographically, the watersheds are also similar. The relatively flat uplands drop off rapidly to steep slopes. The tributary valleys are

deeply incised, having narrow flood plains. The Elk Creek watershed varies in elevation from 950 ft to 1250 ft, and the two watersheds in the Cedar Creek basin vary from 750 to 1000 ft.

Field inspections confirmed the basic data concerning physiography of the three watersheds. The two watersheds in the Cedar Creek basin have substantially more timber than the Elk Creek watershed. There has been considerable coal mining activity in the two Cedar Creek watersheds, which has affected surface conditions to some extent.

It was concluded that there was substantial physiographic similarity between the three watersheds. Because of the cost of installing and operating hydrologic networks, there appeared to be little justification for duplication of effort. Therefore, it was recommended in 1967 that the Elk Creek "bench mark" station replace the Honey Creek watershed in the intermediate size watershed program. It should be noted also that this new stream gaging station will supplement regionally the gaging station presently existing on the Weldon River, the latter having 104 sq mi gaged at Leon.

It was also determined that the recording precipitation gage previously installed in the Honey Creek watershed could be used to an advantage in the Paint Creek watershed. This installation change was completed in the fall of 1967.

Northern Iowa Flat Drainage Areas for Hydrologic Analysis

The additional need for establishing a hydrologic network in a typical "drainage district" watershed in north-central Iowa also was included in the most recent discussions. The East Fork Hardin Creek

watershed serves as this type of flat terrain having drainage problems in agricultural production and use. However, a smaller area, perhaps one drained entirely with agricultural tile, is under consideration. Typical drainage-ditch or drainage district areas in north-central Iowa are tabulated in Table 2. Small agricultural watersheds within these drainage areas can be evaluated for one which would satisfy the desired network requirements.

Table 2. List of watersheds representing the flat "drainage-ditch" areas in north central Iowa.

No.	Name and location
1	Beaverdam Creek — Cerro Gordo and Franklin County West line Sec 17-94-20, 72.4 sq mi
2	Bailey Creek — Cerro Gordo and Franklin County West line Sec 34-94-21, 64.8 sq mi
3	Buffalo and Otter Creeks — Franklin County Sec 5-92-20, 72.6 sq mi
4	Drainage Ditch #6 to Maynes Creek — Franklin County Sec 29-91-20, 29.6 sq mi
5	Maynes Creek — Franklin County West line Sec 22-91-20, 71.0 sq mi
6	Pilot Creek — Pocahontas and Palo Alto County West line Sec 22-93-32, 53.2 sq mi
7	North Branch Lizard Creek — Pocahontas County North line Sec 16-93-33, 49.9 sq mi
8	Mud Lake D.D. #71 — Hamilton County North line Sec 28-87-24, 64.1 sq mi
9	Eagle Creek — Wright County North line Sec 17-91-25, 62.8 sq mi
10	Luick's Creek — Wright County North line Sec 4-92-23, 36.6 sq mi

SUMMARY OF PRECIPITATION AND RUNOFF DATA

The following analysis is made of the precipitation recorder charts:

- Hourly and daily precipitation amounts are extracted and tabulated from the original charts.
- Monthly and annual precipitation amounts are tabulated.
- Individual storm analysis is made of maximum rainfall intensities, 5 min through 24-hr durations, and tabulation of clock 20-min rainfall amounts for all storms meeting the US Weather Bureau intensity criteria.
- A comparison of rainfall records with records of the nearest climatological data station is made. These C.D. stations are:

Watershed	Nearest climatological data station
Paint Creek	Waukon, Iowa
East Fork Hardin Creek	Jefferson, Iowa
David's Creek	Audubon, Iowa

The monthly and annual precipitation amounts at each station are tabulated on Tables 3-5. Also shown are the comparative USWB precipitation station annual values and the USGS calendar year average annual runoff, in inches-on-the-basin, for each of the three watersheds.

Record or near-record amounts of precipitation were received in many locations in Iowa in June 1967. A new monthly maximum was recorded at Red Oak, Iowa, of 22.18 in. Amounts received at the precipitation stations in the study watersheds, along with stream runoff amounts for June and July 1967, are shown in Table 6.

Table 3. Monthly and annual precipitation in inches for Paint Creek watershed precipitation station near Waterville.

	Monthly and annual precipitation, in.														
	Year														
Month	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
Jan	0.44*	0.38	0.26	0.08	0.07	0.21	0.52	0.97	0.12	0.13	0.26	0.29	0.58	0.93	1.93
Feb	2.16*	0.22	0.44	0.20	0.00	0.00	1.83	0.36	1.52	1.03	0.62	0.25	0.67	1.71	0.45
Mar	1.27*	0.79	0.55	2.57	1.19	0.31	2.05	1.02	3.23	1.92	2.08	1.60	2.00	2.32	2.19
Apr	3.41*	6.15	4.06	2.96	2.98	2.03	1.96	3.70	2.09	1.25	2.32	3.98	4.08	2.37	1.77
May	1.78	2.71	3.71	5.22	4.53	1.56	5.68	6.99	1.93	4.06	2.04	6.79	4.73	2.30	2.32
June	3.87	5.23	3.46	1.56	7.42	2.27	7.17	2.79	1.65	2.93	1.82	2.67	3.28	3.25	4.89
July	7.14	2.64	5.87	4.78	7.31	2.53	2.27	3.23	5.87	5.56	3.84	0.86	2.24	5.54	0.45
Aug	3.64	3.34	0.37	4.20	3.57	2.61	6.96	6.35	2.34	5.20	1.96	4.76	4.37	0.83	1.47
Sept	0.26	2.02	1.02	1.49	1.30	2.59	4.12	2.61	10.75	2.10	2.47	3.19	0.65	1.04	2.96
Oct	0.43	3.31	1.63	1.43	1.45	0.65	2.25	3.02	2.77	2.73	0.79	0.30	1.74	1.48	2.91
Nov	1.57	0.39	0.38	1.89	1.39	1.60	2.40	0.49	3.35	0.12	1.16	0.79	2.06	0.43	0.71
Dec	1.12	0.35	0.17	0.19	0.76	0.23	1.78	0.40	0.86	0.51	0.33	0.74	2.58	1.02	1.16
Paint Creek yearly total (Waukon 8 SE)	27.09*	27.53	21.92	26.57	31.98	16.59	38.99	31.93	36.48	27.54	19.69	26.22	37.98	23.22	23.21
Waukon* yearly total	E28.87	E31.30	24.18	E28.25	E27.30	E18.38	D39.45	E31.85	E29.65	E26.79	18.45	E24.78	E37.80	19.94	19.36
Annual runoff, in.**	6.87	4.52	3.81	3.74	2.86	1.20	6.73	5.24	6.99	7.31	4.00	1.96	7.50	3.55	3.80 (estimated)

*US Weather Bureau, nonrecording rain gage in Waukon
E – amount is wholly or partially estimated
D – water equivalent of snowfall wholly or partly estimated, using a ratio of 1 in. water equivalent to every 10 in. of new snowfall.

**USGS Records, calendar year.

Table 4. Monthly and annual precipitation in inches for East Fork Hardin Creek precipitation station near Jefferson, Iowa.

Month	Monthly and annual precipitation, inches — Year 1963	1964	1965	1966	1967
Jan	—	0.40	0.93	0.76	0.85
Feb	—	0.38	1.45	0.29	0.18
Mar	—	1.04	3.27	1.49	1.02
Apr	—	7.03	3.69	0.76	2.10
May	—	3.46	3.04	2.80	1.46
June	—	2.87	3.09	7.92	13.93
July	—	2.36	2.01	1.44	1.04
Aug	5.66	4.01	2.74	1.85	1.86
Sept	1.85	1.76	9.65	0.19	2.44
Oct	0.54	0.54	0.90	0.85	0.70
Nov	0.57	0.85	0.59	0.20	0.20
Dec	0.59	0.70	1.20	0.47	0.32
East Fork Hardin yearly total (Jefferson 9N)	9.21 (Aug-Dec)	25.40	32.56	19.02	26.10
Jefferson* yearly total	12.45 (Aug-Dec)	35.95	37.23	19.77***	27.88E
Annual runoff, in.**	3.05	6.22	7.28	4.56	5.2 (estimated)

*US Weather Bureau, nonrecording rain gage in Jefferson (5SW)
E — amount is wholly or partially estimated
D — water equivalent of snowfall wholly or partly estimated, using ratio of 1 in. water equivalent to every 10 in. of new snowfall.
**USGS Records, calendar year.
***Lake City record, no record for Jefferson.

Table 5. Monthly and annual precipitation in inches for David's Creek watershed precipitation station near Audubon, Iowa.

Month	Monthly and annual precipitation, in. Year 1966	1967
Jan	–	0.88
Feb	–	0.22
Mar	–	1.46
Apr	–	2.10
May	–	2.19
June	–	13.20
July	–	1.34
Aug	–	0.87
Sept	0.57	2.58
Oct	0.31	1.64
Nov	0.20	0.10
Dec	0.53	0.49
David's Creek yearly total (Audubon 9E)	1.61 (Sept-Dec)	27.07
Audubon* yearly total	2.31 (Sept-Dec)	30.54
Annual runoff, in.**	4.56	4.0 (estimated)

*US Weather Bureau, nonrecording rain gage in Audubon
E – amount is wholly or partially estimated
D – water equivalent of snowfall wholly or partly estimated, using a ratio of 1 in. water equivalent to every 10 in. of new snowfall.

**USGS Records, calendar year.

Table 6. Rainfall and stream runoff, June and July 1967.

Station	June		July	
	Rainfall, in.	Runoff, in.	Rainfall, in.	Runoff, in.
Paint Creek	4.89	0.11	0.45	0.06
East Fork Hardin Creek	13.93	4.59	1.04	0.47
David's Creek	13.20	2.94	1.37	0.38

PRELIMINARY STUDIES OF THE PAINT CREEK HYDROLOGIC RECORD

Several analyses have been made of the hydrologic data collected in the Paint Creek watershed and are summarized in this section. An aerial mosaic of the watershed was constructed and is included as Fig. 1. This figure indicates that soil conservation practices, such as crop rotation, land contouring, terracing, etc., are predominant in the watershed. These practices could explain the fact that the volumes of direct surface runoff are low, and the average watershed yield during the period of record, 4.73 in., is below the regional mean in this part of the state, even though the base flow is good. During the storm of record on Paint Creek, July 25-26, 1953, a total of 4.4 in. of rainfall fell in 24 hr. Direct surface runoff was estimated as 0.8 in., or 18% of the average precipitation.

Rainfall Intensity-Duration-Frequency Analysis

The results of individual storm analysis for Paint Creek are summarized in Table 7. The tabulated amounts are the annual maximum rainfall intensities for the indicated duration, from 5 min to 24 hr. The results, for the period 1953-1966, are plotted in Fig. 3. The results compare favorably, for two to ten-yr frequency values, with those of surrounding US Weather Bureau stations as reported in recent publications[6,7].

Table 7. Annual maximum rainfall intensities, Paint Creek watershed, Allamakee County, Iowa.

Calendar year	Maximum intensities, inches per hour, for indicated durations								
	5 min	10 min	20 min	30 min	1 hr	2 hr	6 hr	12 hr	24 hr
1953*	3.36	2.52	1.65	1.34	1.25	0.76	0.41	0.36	0.18
1954	4.08	3.12	2.16	1.80	1.28	0.66	0.24	0.14	0.08
1955	6.00	5.58	3.84	2.86	1.66	0.84	0.28	0.14	0.08
1956	4.20	3.30	2.61	2.60	1.67	0.84	0.29	0.15	0.08
1957	4.80	4.20	3.30	2.62	1.31	0.84	0.48	0.24	0.12
1958	2.88	2.64	1.59	1.26	0.66	0.34	0.19	0.13	0.06
1959	4.92	4.56	3.60	3.20	1.78	0.92	0.33	0.22	0.11
1960	6.00	4.80	3.06	2.16	1.14	0.84	0.33	0.17	0.08
1961	5.04	4.50	4.05	3.50	2.55	1.37	0.46	0.32	0.18
1962	4.80	4.44	2.43	1.98	1.22	0.80	0.42	0.25	0.12
1963	3.60	2.88	1.83	1.32	0.70	0.40	0.17	0.14	0.08
1964	5.40	3.60	2.37	1.70	1.34	1.00	0.42	0.24	0.12
1965	4.20	2.76	2.49	1.92	1.07	0.56	0.26	0.24	0.12
1966	5.40	4.50	3.45	2.70	2.03	1.06	0.53	0.32	0.19
1967	3.12	2.40	1.44	1.48	0.90	0.55	0.26	0.17	0.08

*May-Dec 1953.

Physiographic Features

An initial study was made of several physiographic variables of the Paint Creek watershed. Here, USDA aerial photos, regional topographic maps, and the soil survey maps of Allamakee County were used to supply the basic data[5].

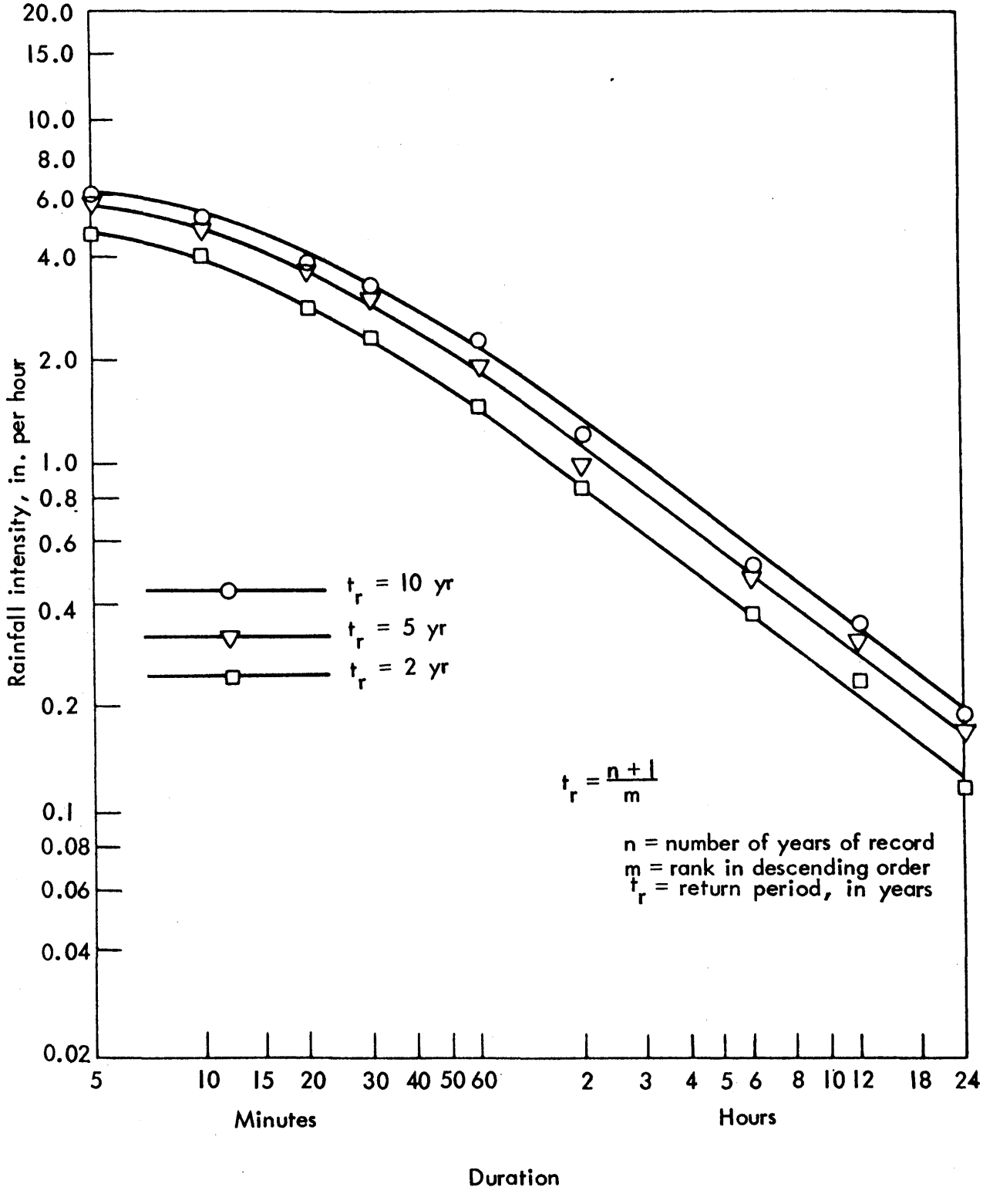

Fig. 3. Rainfall intensity-duration-frequency for the Paint Creek watershed, Allamakee County, Iowa, 1953-1966.

The area-distance histogram of the watershed, which is about 18 mi in total length, is illustrated in Figs. 4 and 5. These diagrams indicate that the largest portion of the watershed is located near the stream gaging station. About 50% of the total gaged area is located within seven miles of the gaging station, with the largest incremental area contribution being made between miles two to five.

These downstream areas also are very steep, especially in comparison with the relatively flat areas at the upstream limits of the watershed. A time-area histogram[8] also is being developed, which will reflect the more rapid time of travel of storm runoff from the steep slopes. This will tend to concentrate even more of the direct surface runoff contribution from the area nearest the stream gaging station. It will also assist in explaining the rapid rise of flood hydrographs and the very sharp peak in the flood crest which was evident in the water stage recorder charts.

The 1958 soil survey report[5] from Allamakee County was used to determine the soil characteristics of the watershed. The dominant soil type is Fayette silt loam, which covers about 49% of the area. The soil types, phases, map symbols, and distribution values are listed in Table 8. The subsoil permeabilities of most of the soils are listed as moderate to rapid[5].

A land use analysis of the Paint Creek watershed is currently being made. The amount of land devoted to agricultural cropland, pasture, timber, farmsteads and roads, and urban areas is being determined. The percentage of the watershed which has been contoured, terraced or strip-cropped is also being computed.

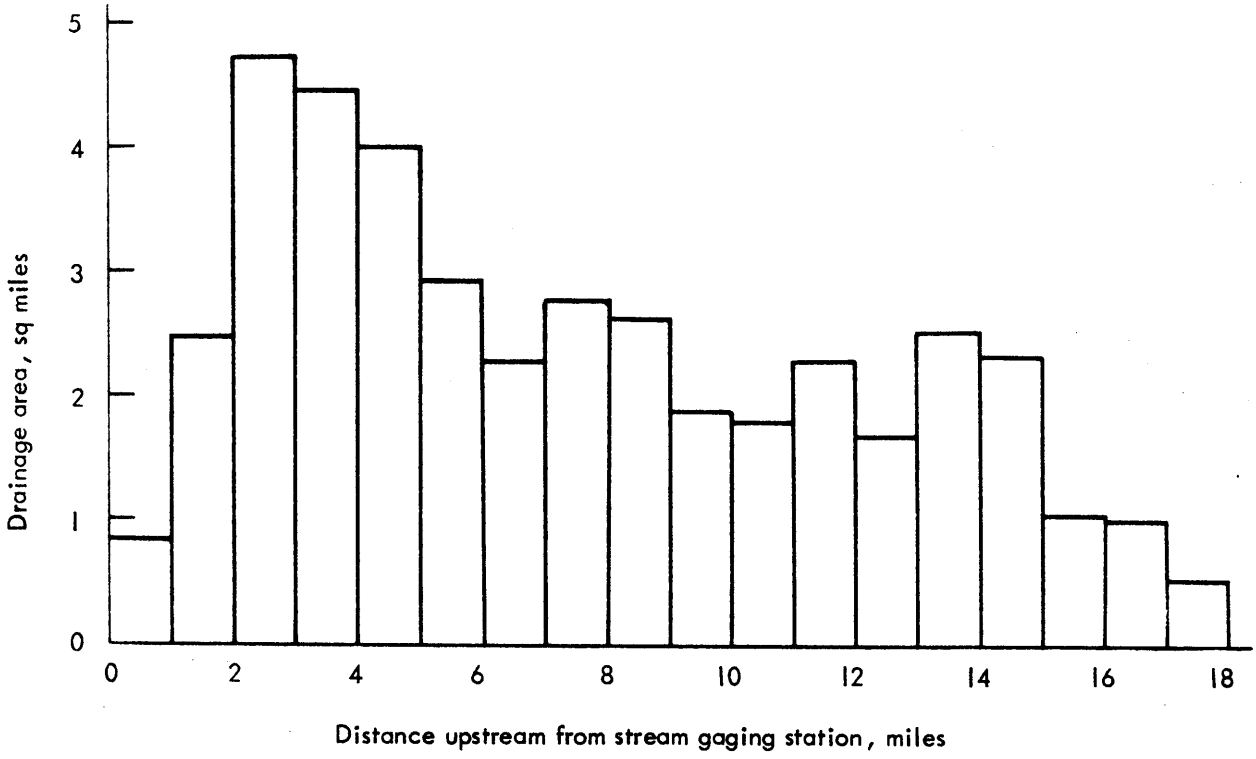

Fig. 4. Distance-area diagram for Paint Creek watershed, Allamakee County, Iowa.

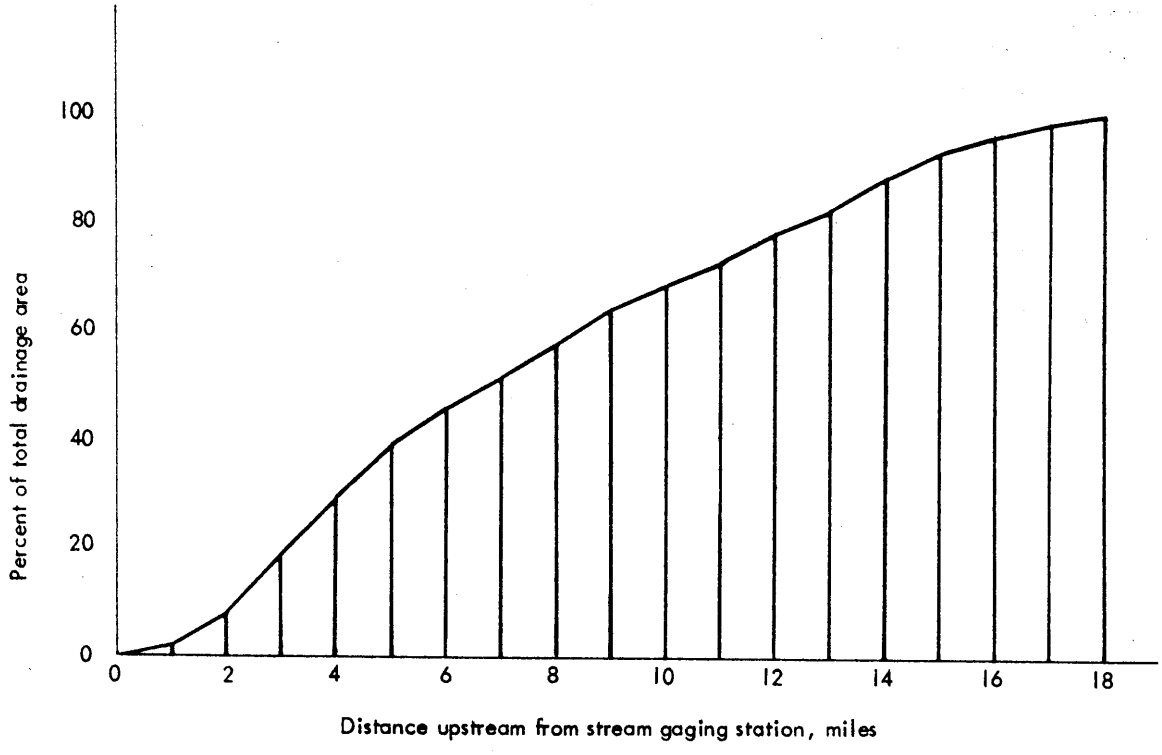

Fig. 5. Drainage area relationship with distance, Paint Creek watershed, Allamakee County, Iowa.

Table 8. Soil characteristics of the Paint Creek watershed, Allamakee County, Iowa.

Soil characteristics			Distribution	
Map symbol	Type	Phase, % slope	Area, sq mi	% of area
Cj	Chaseburg and Judson silt loams	1-2	0.238	0.56
Da	Dodgeville silt loam, eroded	10-16	0.015	0.03
Dc	Dorchester silt loam	0-1	1.690	3.95
Dk	Downs and Tama silt loams	4-7	2.992	6.99
Dl	Downs and Tama silt loams, eroded	8-12	1.277	2.98
Dm	Downs and Tama, bench position	1-4	0.025	0.06
Du	Dubuque silt loam	4-8	0.448	1.05
Dv	Dubuque silt loam, eroded	10-16	5.745	13.41
Fa	Fayette silt loam	4-7	8.335	19.46
Fb	Fayette silt loam, eroded	8-14	12.475	29.13
Ma	Mixed alluvium	2-5	0.840	1.96
Qa	Quandahl silt loam	7-12	0.032	0.08
Qb	Quandahl silt loam	13-16	0.302	0.70
Qc	Quandahl silt loam	17-24	0.115	0.27
Sh	Schapville silt loam	4-7	0.035	0.08
So	Sogn silt loam	4-7	0.248	0.58
Sr	Steep rocky land	18-30	7.845	18.31
St	Steep rocky land	30-60	0.138	0.32
Tb	Tama silt loam, eroded	8-12	0.035	0.08
		Totals	42.830	100.00

PRELIMINARY STUDIES OF HYDROLOGIC RESPONSE AND BEHAVIOR CHARACTERISTICS OF PAINT CREEK WATERSHED

The hydrologic data being collected on the Paint Creek watershed includes stream flow (USGS), precipitation (USWB and INRC), and temperature (USWB). The basic data for these three parameters permit several hydrologic relationships to be studied.

Snowmelt Analysis

The northeast part of Iowa has experienced many snowmelt floods. In many basins, the snowmelt floods have exceeded summer floods in magnitude of discharge and frequency. An initial appraisal of streamflow hydrographs for Paint Creek indicated a uniform, discernible diurnal pattern. This permitted the evaluation of the daily snowmelt runoff contributions. The results for two large snowmelt floods are listed in Tables 9 and 10. These floods occurred in 1961 and 1962. Preliminary correlation of accumulated temperature degree-day values with accumulated inches of runoff[9] has yielded an initial estimate of the melt constant, K, in the equation:

$$M = KD$$

in which M = snowmelt, inches per day

D = number of degree-days for a given day, above 32°F

K = melt constant, varying with watershed and climatic conditions, inches per degree-day per day.

The results of the analysis, using published daily maximum and minimum temperature values, gave average K values varying from 0.08 to 0.12,

Table 9. Snowmelt data for March 1961 spring runoff period, Paint Creek watershed, Allamakee County, Iowa.

Date, in Mar	Temp, °F Hi	Temp, °F Low	Precipitation, in.	Stream flow, cfs	Estimated direct surface runoff, in.
20	40	24	–	12.0	–
21	37	30	0.08	18.0	–
22	36	30	0.07	24.0	0.041
23	41	30	–	143.0	0.168
24	47	27	–	518.0	0.920
25	58	34	–	1,250.0	1.125
26	55	44	–	345	0.221
27	57	35	0.06	187	0.102
28	37	28	–	65	–
29	37	20	–	41	–
30	47	20	–	33	–
31	47	30	–	30	–
				Total	2.577

with maximum daily values exceeding these values. It appears that hourly temperature data are needed to definitely establish the daily minimum temperature in the morning of each specific day. Hourly temperature data from the airport stations at Dubuque and Waterloo are being used in a more complete analysis, which will also include additional snowmelt periods and additional hydrologic variables including wind and humidity. The maximum surface runoff volumes during these two periods, excluding the

Table 10. Snowmelt data for March 1962 spring runoff period, Paint Creek watershed, Allamakee County, Iowa.

Date, in Mar	Temp, °F Hi	Temp, °F Low	Precipitation, in.	Stream flow, cfs	Estimated direct surface runoff, in.
20	37	24	–	6.9	–
21	40	27	–	7.4	–
22	39	24	–	10	0.017
23	37	24	–	23	0.025
24	40	24	–	33	0.043
25	45	30	–	83	0.091
26	43	27	–	120	0.125
27	51	24	–	259	0.582
28	61	42	–	1,440	1.235
29	50	30	0.40	203	0.092
30	34	27	0.23	68	0.053
31	34	22	0.38	51	–
				Total	2.263

base flow of the stream, were 2.26 and 2.58 in., with maximum day values of 1.2 in. These values show that snowmelt runoff can exceed summertime direct surface runoff values estimated for rainfall amounts commonly used in design. Therefore, snowmelt estimates may be equally as important, or even more important, in hydrologic and engineering studies than rainfall analysis in this part of the state.

Determining Critical Storm Duration in Flood Hydrology Studies

One additional hydrologic relationship has been evaluated briefly. Using the unit graph and S-curve techniques of Linsley, Kohler, and Paulhus[8], the average unit graphs for various storm durations, from one to twelve hr, were developed for Paint Creek. These unit graphs were then combined with design rainfall-runoff relationships developed for Paint Creek, using Soil Conservation Service and Bureau of Reclamation methods[10]. Because the peak discharge of the unit graph decreases with duration, but direct surface runoff values increase, it was reasoned that for small or intermediate size watersheds, the peak discharge could reach an optimum or maximum value for a given storm frequency. The critical duration for Paint Creek varied from four hours at a 100-yr frequency to six hours at a 10-yr frequency level. The results are shown in Fig. 6. More detailed analysis of this relationship will be made in the final year's study. The concept of a critical storm duration is especially meaningful in peak discharge studies, culvert and bridge designs, and reservoir hydrology studies.

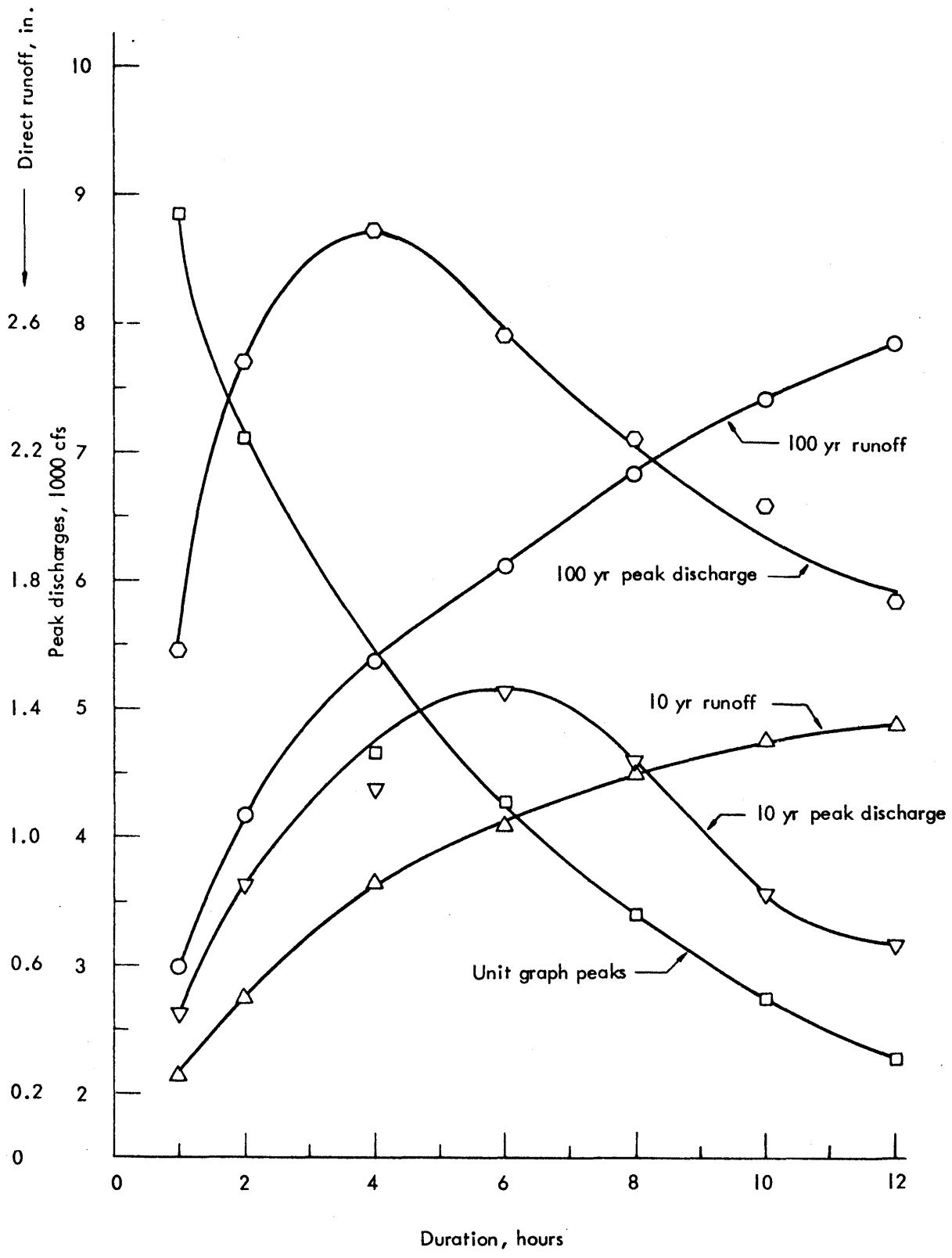

Fig. 6. Runoff and peak discharge vs duration for the Paint Creek watershed, Allamakee County, Iowa.

Watershed Yield and Gross Reservoir Storage Requirements

The Paint Creek hydrologic record has been included in a study by Shearman[11], in which determinations were made of gross reservoir storage requirements to meet uniform water supply or low-flow demands. Nine intermediate-size watersheds in Iowa were included in this study. Hydrologic parameters included in the watersheds studied, precipitation, land pan and associated lake evaporation, streamflow, topographic and reservoir storage-area relationships, and variable demand rates. The Paint Creek watershed exhibits excellent low flow characteristics, with a well-sustained base flow. As a result, both net and gross reservoir storage requirements are less than in the other Iowa watersheds studied.

The study also indicated that inclusion of all hydrologic variables in reservoir storage studies, using monthly operation methods, provides the most realistic solution compared to the use of net reservoir storage methods with the addition of an arbitrary amount of lake or reservoir evaporation. Reservoir shape factors, expressed as volume-area relationships, were also studied by Shearman.

SUMMARY

The precipitation stations in the hydrologic network for the study of intermediate-size watersheds have been reestablished and/or continued in operation. Additional coordination by the Iowa Natural Resources Council is recommended to assure that the hydrologic instrumentation of a southern Iowa "bench mark" basin in Elk Creek is established and thereafter operated as a replacement for the Honey Creek watershed. Coordination to assure that a small, flat-drainage area is selected and instrumented in central or northern Iowa is also recommended.

The hydrologic data for the three study watersheds, Paint Creek, East Fork Hardin Creek, and David's Creek, have been summarized. Several additional hydrologic studies have been initiated for the Paint Creek watershed. Additional detailed study of snowmelt, flood hydrographs, and critical storm durations is warranted during the third year of the project. A fifteen-year analysis of the hydrology of the Paint Creek watershed will be made during this period.

FINANCIAL SUMMARY

The approved three-year budget for financial support by the Iowa Natural Resources Council was as follows:

Item		FY 1967	FY 1968	FY 1969
1.	Salaries, including benefits	$645	$645	$3870
2.	Travel and supplies	100	100	300
3.	Report preparation	—	—	500
	Subtotals	$745	$745	$4670
4.	Overhead, 20%	149	149	934
	Total	$894	$894	$5604

Three year total	$7392
Amount received FY 1967 and 1968	1788
Unpaid balance, June 30, 1968	$5604

The expenditures for the first two years, fiscal years 1967 and 1968, were as follows:

Item		Expenditures
1.	Salaries	$ 903
2.	Travel and supplies	622
3.	Report preparation	85
	Subtotal	$1610
4.	Overhead, 20%	322
	Total	$1932
	Budgeted	$1788
	Excess of expenditures over budgeted allocation, to be applied to FY 1969 funds.	$ 144

Expenditures for travel and supplies have been greater than budgeted figures because of the additional watershed investigations in southern Iowa. Salaries include hourly wages for graduate and undergraduate civil engineering students and for payments to the precipitation station observers. Through the work-study program involving federal assistance, one civil engineering student was supported with 90% federal funds, 10% State funds. A graduate student will be appointed in fiscal year 1969 to complete the hydrology study and prepare a terminal report.

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