UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER RESOURCES DIVISION
GEOLOGICAL SURVEY

WATER RESOURCES OF THE ENGLISH RIVER, OLD MANS CREEK, AND CLEAR CREEK BASINS IN IOWA

By
Harlan H. Schwob
Hydraulic Engineer, USGS

Prepared in Cooperation with
THE IOWA NATURAL RESOURCES COUNCIL

Open-file Report
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Iowa City, Iowa
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ABSTRACT

The surface and ground water resources of a 991 square mile area comprising the drainage basins of English River, Old Mans Creek and Clear Creek are presented. These basins lie to the west and southwest of Iowa City, Iowa, and all three streams are tributary to the Iowa River. The area is comprised of rolling uplands with relatively broad valleys and is devoted mainly to agriculture and livestock farming.

In general, the surface water use is adversely affected by the high variability of flows and particularly by the critically small minimum flows. Augmentation of the minimum flows by means of storage reservoirs is possible but may be uneconomical in the broad valleys which require a high area to volume ratio.

The surface water supply is presented in the form of tables and graphs which show information on maximum and minimum flows, mean flow, duration of flow, frequency of low flow and flood flow and storage requirements. Low-flow discharge profiles for the English River and South Fork English River derived from measurements at partial record and supplementary sites are also shown.

Ground water is available from shallow wells in nearly all of the area; however, the wells vary widely in productivity and reliability during a drouth. Potentially excellent aquifers may be found in the alluvium which underlies the valleys since similar areas along the lower Iowa River basin have produced yield up to 100 gallons per minute. However, the best and most reliable source of good ground water is the Jordan Sandstone. This aquifer varies from 1,375 feet below ground level in the eastern part of the area to 2,200 feet below ground level at the western end of the area. It is capable of supplying as much as 1,000 gallons per minute to individual wells. Its location is shown in the report by means of map contours referenced to mean sea level.

WATER RESOURCES OF THE ENGLISH RIVER, OLD MANS CREEK AND CLEAR CREEK BASINS IN IOWA

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INTRODUCTION

This report describes the water resources of an area in the southeastern quarter of Iowa. Three basins, those of English River, Old Mans Creek and Clear Creek, lying west and southwest of Iowa City and having an aggregate drainage area of 991 square miles, are covered in the report. The basins are a part of the much larger Iowa River basin.

In 1955 the Iowa Natural Resources Council (INRC) published Bulletin 2, "Water Resources and Water Problems of the Iowa-Cedar River Basin". That report presented a broad general picture of the water resources and problems of the large basin.

The present report enlarges upon, extends in detail, and updates through 1963 that portion of the 1955 report covering the water resources of the smaller three-basin area. Insofar as possible, duplication of the material in the 1955 report has been avoided. Instead, the intent is to supplement the former report with up-to-date information needed by the INRC and the water manager for use in the smaller area.

The report has been prepared as part of a cooperative project between the Iowa Natural Resources Council (INRC) and the U. S. Geological Survey (USGS) for the study of low flow of Iowa streams. The council is charged with the administration of the Iowa Water Law and requires streamflow information to perform this administration.

Present uses of surface water in these three basins are for recreation, waste disposal, and maintenance of aquatic life. No city water supplies are dependent on surface water from streams in the basins nor is surface water being used for cooling purposes. One irrigation permit, on Old Mans Creek, for 1.11 cfs, has been issued by the INRC.

Ground water supplies are used for both rural and urban needs except for Coralville. This city presently obtains its water from Iowa City which in turn takes its water from the Iowa River. Both shallow and deep wells are used in the three-basin area, depending upon the requirements to be served.

The adequacy of the water resources of the area to meet prospective demands depends upon the availability and variability of the supply. The surface water resources are described by mean discharge, duration of flow, storage requirements, and profiles of low discharge. Ground water resources are described by the variable amounts available at shallower depths and the dependable supply furnished by the aquifer of the Jordan Sandstone at much greater depths.

Presentation of the data is in the form of maps, tables and graphs whenever possible. Also, the basic information such as gaging-station descriptions and measurements of flow, though discussed briefly in the body of the report, have been placed in an appendix.

ACKNOWLEDGMENTS

The geological and ground water information has been furnished from the cooperative program of the Iowa Geological Survey and the Ground Water Branch, USGS. It was prepared by Walter L. Steinhilber District Geologist, Iowa District USGS. The Corps of Engineers, Rock Island District, furnished gage-height records and discharge measurements for Old Mans Creek. These data, though the gage-height records were somewhat framentary, were extremely valuable in that part of the study covering Old Mans Creek. Both the Iowa Geological Survey and the Corps of Engineers cooperate in the regular stream-gaging programs in these and nearby basins. Flood frequency data is from a preliminary report being prepared in a cooperative project with the Iowa Highway Research Board. Except as previously mentioned the collection of data and analyses are the work of the U. S. Geological Survey.

DESCRIPTION OF BASINS

Location

The three basins studied are in the southeast quarter of Iowa. All three streams are right-bank tributaries of the Iowa River below the Coralville Flood Control Reservoir. As shown by the map of Plate 1; the combined basins, roughly shaped like a triangle, lie to the west and southwest of Iowa City. The center of the area is about 30 miles south of Cedar Rapids, 85 miles east of Des Moines, and 75 miles west of Davenport.

Parts of six counties are included in the area. These counties, in a clockwise direction from the northeast corner, are Johnson, Washington, Keokuk, Mahaska,1/ Poweshiek and Iowa.

The three-basin area is oriented in a general east-west direction. Main stems of the streams generally flow from the west toward a point slightly south of east. The areas and other dimensional characteristics of the basins are shown in table 1.

1/ About two square miles are drained by the South English River.

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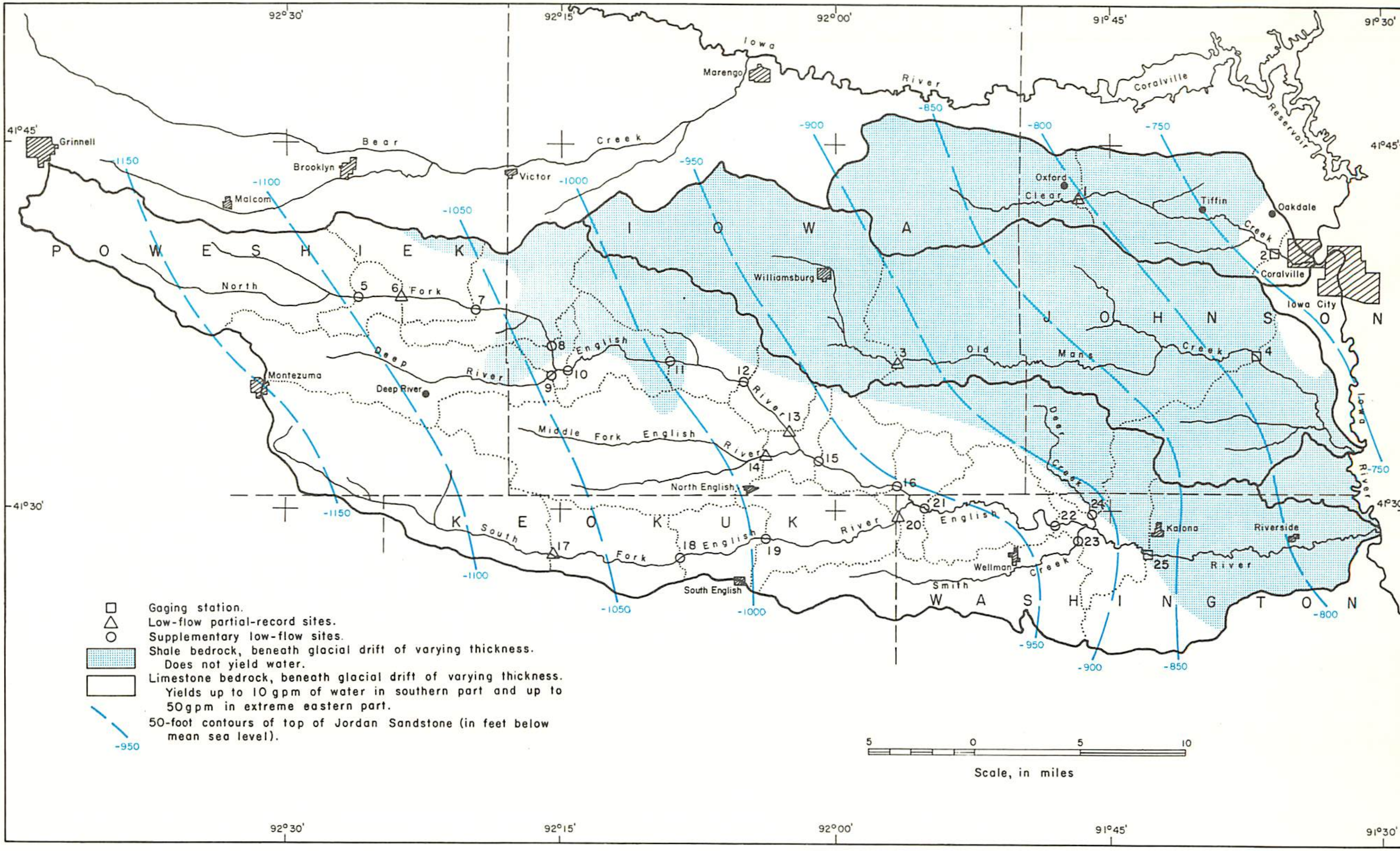

Plate I. Map showing drainage basins of English River, Old Mans Creek and Clear Creek with superimposed geologic data.

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Table 1.- Dimensional Characteristics of English River, Old Mans Creek and Clear Creek Basins

Basin	Point	Miles above mouth of Iowa R.	Drainage area sq. mi.	Basin dimensions (miles) above selected point			Ground elev.[b] (range in basin) ft. above msl	
				Length	Max. width	Aver. width	High	Low
English River	Mouth	53.7[a]	638	65.5	16.8	9.7	1020	600
	Gage	67.0	573	55.2	16.8	10.4		
Old Mans Creek	Mouth	61.3[a]	248	38.3	10.6	6.5	925	620
	Gage	69.9	201	32.4	10.6	6.2		
Clear Creek	Mouth	77.9[a]	105	23.1	6.7	4.5	935	650
	Gage	80.1	98.1	21.3	6.7	4.6		

a Determined from Corps of Engineers profiles of Iowa River
b Approx.-- from available maps

Transportation

The area is well supplied with both road and railroad facilities. Interstate Highway 80 runs east and west through the north one-quarter of the area. State or Federal highways cross the basins in a north-south direction and within or near the basins in an east-west direction. A grid of local county and farm-to-market roads (many of the latter are hard surfaced) covers the area. Available maps indicate that no point in the area is more than a mile from a county road or 8 miles from a State or Federal highway.

Railroad facilities are likewise generally available near all points in the area. Three north-south railroads cross the basins including one at each end. East-west railroads lie on or near the north and south boundaries of the basins. No point in the area is more than 10 miles from a rail line although, in a few cases, distances to loading sites may be somewhat greater.

Air transportation is provided by two airports - the Iowa City airport near the northeast corner of the area and the Cedar Rapids airport about 25 miles north of the center of the area.

Industrial Development

No large industries are located in the three basins. Small industrial developments, generally allied to agriculture or housing are growing along the lower end of Clear Creek in or near Coralville. Commercial and housing developments are likewise expanding in this area.

Topography and Land Use

All three basins have about the same topographic features. The streams have relatively broad and flat flood plains with constantly meandering low-water channels except for reaches that have been straightened. The uplands are dissected by tributary streams and form rolling hills with flat areas on the divides. The total range in relief in each basin is shown in table 1.

The difference in elevation from flood plain to divide along the main streams and major tributaries is indicated on available maps to be about 125-150 feet. Large scale topographic maps are available only for the Iowa City quadrangle (Lat. 41°30' to 41°45', Long. 91°30' to 91°45') and this sheet is in need of extensive culture revision.

The basins are primarily used for agriculture and livestock operations. All types of agricultural crops common to Iowa are raised in the area. Similarly all types of livestock and poultry are produced. The basins of Old Mans Creek and English River are the site of many large turkey production operations and a processing plant for turkeys is located at Kalona in the English River basin.

The upland areas and the higher portions of the main stem valley floors are cultivated. A few small timbered areas can be found in the upland areas, however, most timbered areas are located along the streams or in permanent pastures in the flood plain.

Climate

The climate of the three-basin area is temperate; mean annual temperature is nearly 50° and the mean annual rainfall from 30.7 to 32.7 inches. Table 2 contains monthly and yearly normals of precipitation and temperature from the U. S. Weather Bureau Climatological Data. Normals are those computed by the Weather Bureau for the standard 1931-60 period.

Population

Table 3 indicates the population of each basin in the area. Basis for the table is the 1960 census and maps derived from this census. In the census, rural population was given only as a total for each civil township. When basin divides crossed a township it was necessary to estimate the portion of the population within the basin area. Similar estimates were required for towns located on a divide.

Table 2. 1931-60 normal temperatures (in degrees Fahrenheit) and precipitation (in inches) for selected Weather Bureau Stations in Iowa

Station	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Williamsburg	Temp.	21.8	25.4	35.4	49.8	61.2	70.8	75.4	73.2	65.0	54.1	38.0	26.5	49.7
	Precip.	1.25	.95	1.94	2.63	3.76	4.75	3.56	3.16	3.10	2.30	2.07	1.25	30.72
Grinnell	Temp.	21.2	24.8	35.0	49.6	61.1	70.8	75.8	73.7	65.2	54.0	37.2	25.9	49.5
	Precip.	1.35	1.05	2.15	2.71	4.40	4.98	3.58	3.53	3.62	2.26	2.17	1.35	33.13
Iowa City	Temp.	-	-	-	-	-	-	-	-	-	-	-	-	-
	Precip.	1.38	1.15	2.14	2.98	3.83	4.81	3.87	3.49	3.22	2.40	2.07	1.44	32.68
East central district	Temp.	22.1	25.5	35.4	49.7	60.7	70.4	75.0	73.2	64.8	53.9	38.0	26.6	49.6
	Precip.	1.46	1.19	2.27	3.10	3.94	4.80	3.41	3.49	3.32	2.44	2.04	1.51	32.97

Table 3.- Basin Population from 1960 Census

Clear Creek basin

Total basin population, 5,616

Total basin rural population, 1,822

Towns over 250 population	County	Population
Coralville	Johnson	2,100[a]
Oakdale	Johnson	750
Oxford	Johnson	633
Tiffin	Johnson	311
		3,794 Total

Old Mans Creek basin

Total basin population, 6,129

Total basin rural population, 4,787

Towns over 250 population	County	Population
Williamsburg	Iowa	1,342
		1,342 Total

English River basin

Total basin population, 15,030

Total basin rural population, 10,221

Towns over 250 population	County	Population
Deep River	Poweshiek	329
Kalona	Washington	1,235
Montezuma	Poweshiek	500[b]
North English	Iowa	1,004
Riverside	Washington	656
Wellman	Washington	1,085
		4,809 Total

a Estimated--total population 2,357

b Estimated--total population 1,416

Waste Disposal

Many rural homesteads have been modernized with pressure water systems, and septic tanks for waste disposal. Similarly many of the smaller towns have no public sewer systems and septic tanks furnish the means for waste disposal.

Within the area, published reports[1/] indicate six towns (including Oakdale TB Sanatorium) have public sewerage and discharge treated waste into streams. These six are Oakdale, Oxford, Williamsburg, Riverside, Wellman, and North English. Three communities, Grinnell, Coralville and Montezuma, discharge their wastes into streams in other basins. One community, Homestead, uses sewage lagoons for treatment of wastes.

Stream-Gaging Stations

Three stream-gaging stations are located in the area--one on each of the three streams. Those on the English River and Clear Creek are operated by and records computed by the USGS. These two stations are equipped with recording gages. A wire-weight gage has been operated on Old Mans Creek by the Corps of Engineers, U. S. Army in connection with the operation of the Coralville Flood Control Reservoir. Regular measurements of discharge have been made and a somewhat framentary gage-height record collected at this gage. Daily records for the site, using the available data, have been computed and used for studies in this report. The daily records will be published in the 1964 report "Surface Water Records of Iowa".

In addition to the data collected at the three gages, discharge measurements have been made at other sites in the basins. These measurements are classified as data at partial-record stations and at supplementary sites. The partial-record data consist of one or more low-flow measurements made each year since 1957. The supplementary data are measurements made during three periods of low flow in 1963.

[1/] See selected references

The sites of the gaging stations, the partial-record stations and the supplementary measurements are all indicated by symbol on the map of plate 1. They are further identified by means of a number on the map--the gaging stations being numbered 2, 4, and 25.

Descriptions are shown in the appendix for all three types of stations and are keyed to the map of plate 1 by numbers. The measured discharge at partial-record and supplementary sites is listed with the descriptions; at gages the daily discharge for the date of the measurements at other sites along the stream is listed.

The gage on the English River at Kalona has been operated since September 1939; the other two gages have a much shorter period of record (see appendix). The longest common period of operation of the three is the 1953-63 water years, that is, from September 1, 1952 to September 30, 1963.

SURFACE WATER SUPPLIES

Records of streamflow at gages and other sites provide the basic data for assessing the ability of a stream to meet the demands placed upon its flow. The results produced by computations using discharge measurements and gage-height records are published as daily streamflow rates in USGS water-supply papers[1/]. These papers also show monthly and yearly data in the form of totals, means, volumes (run-off inches, acre-feet and second-foot days) and maxima and minima. Detailed records of this nature provide useful and desirable information for many purposes. They also provide the raw-material for the analyses of trends in streamflow to show the potential assured yield of the basin. In the following sections the results of analyses made of the data for the three streams are discussed. These results are shown on illustrations wherever possible.

1/ See selected references.

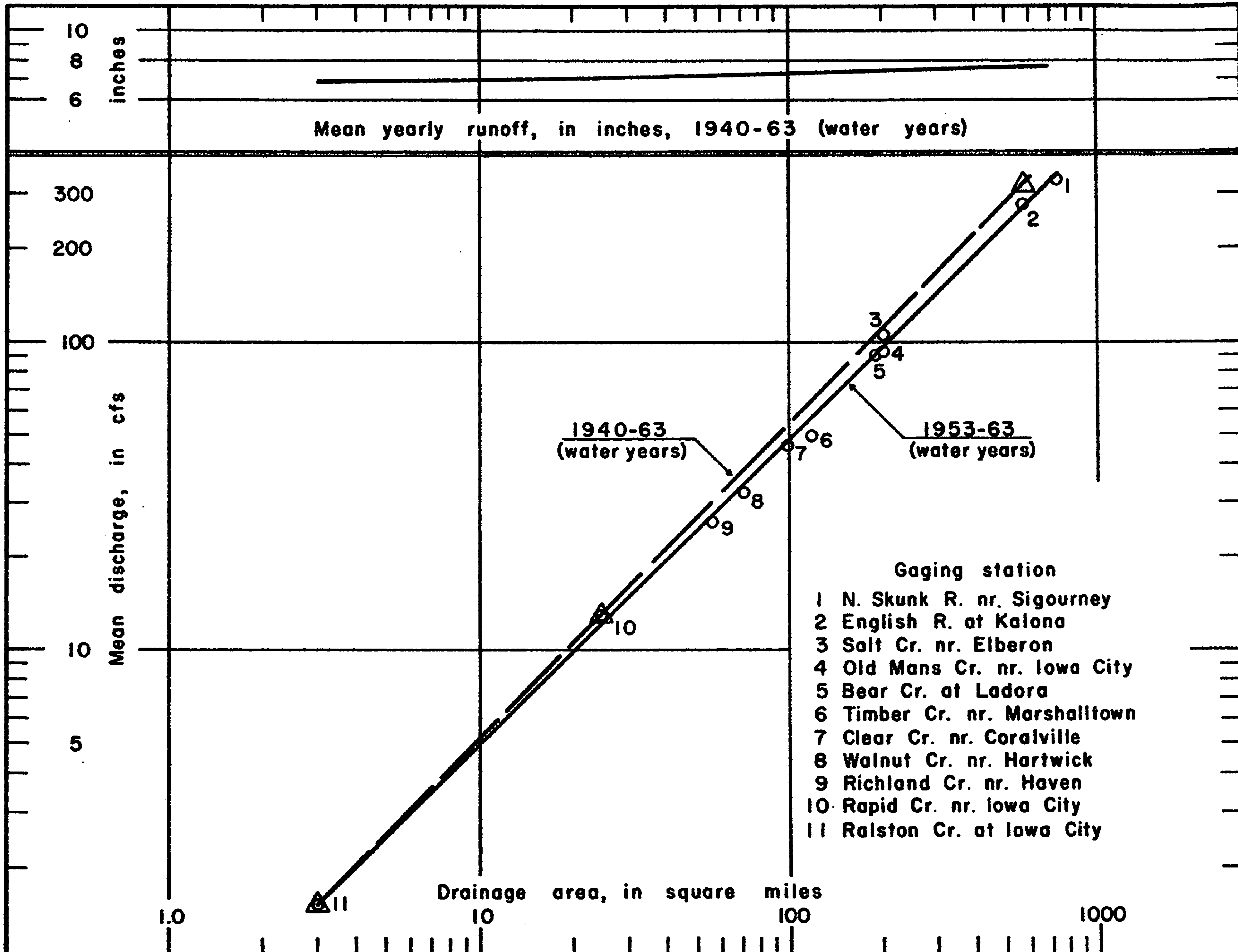

Figure 1. Variation of mean discharge with drainage area.

Mean Discharge

The mean or average discharge of a stream over a long period of time is the limiting amount of water available for use. The mean discharge of the streams of the three-basin area has been shown on figure 1. Means for the 11-year period common to the three gaging station records have been computed for those stations and for nearby stations. Three of the stations including English River have records for the 1940-63 period; the means for these stations for the 24-year period were also computed and used as shown on figure 1. This figure can be used to determine the mean flow for ungaged sites within the basins.

Duration of Flow

Duration of flow is an important consideration in the utilization of surface water in the area. The high variability of flow and lack of sustained low flow, as indicated by the steepness of the curves and the lack of flattening at the lower end, is shown on figure 2. This figure also indicates that the flow is less than the mean about 80 percent of the time and that major uses of surface water will require storage. Storage requirements are discussed in a later paragraph. The methods used to determine such curves or tables from discharge records are explained in detail in Water Supply Paper 1542-A entitled "Flow-duration Curves"and available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. The curves (or tables) show the percent of time during which a selected discharge was equalled or exceeded. Because a flow-duration curve shows the distribution of discharges for a selected period of record, it will usually differ from curves at the same station computed for shorter or longer periods.

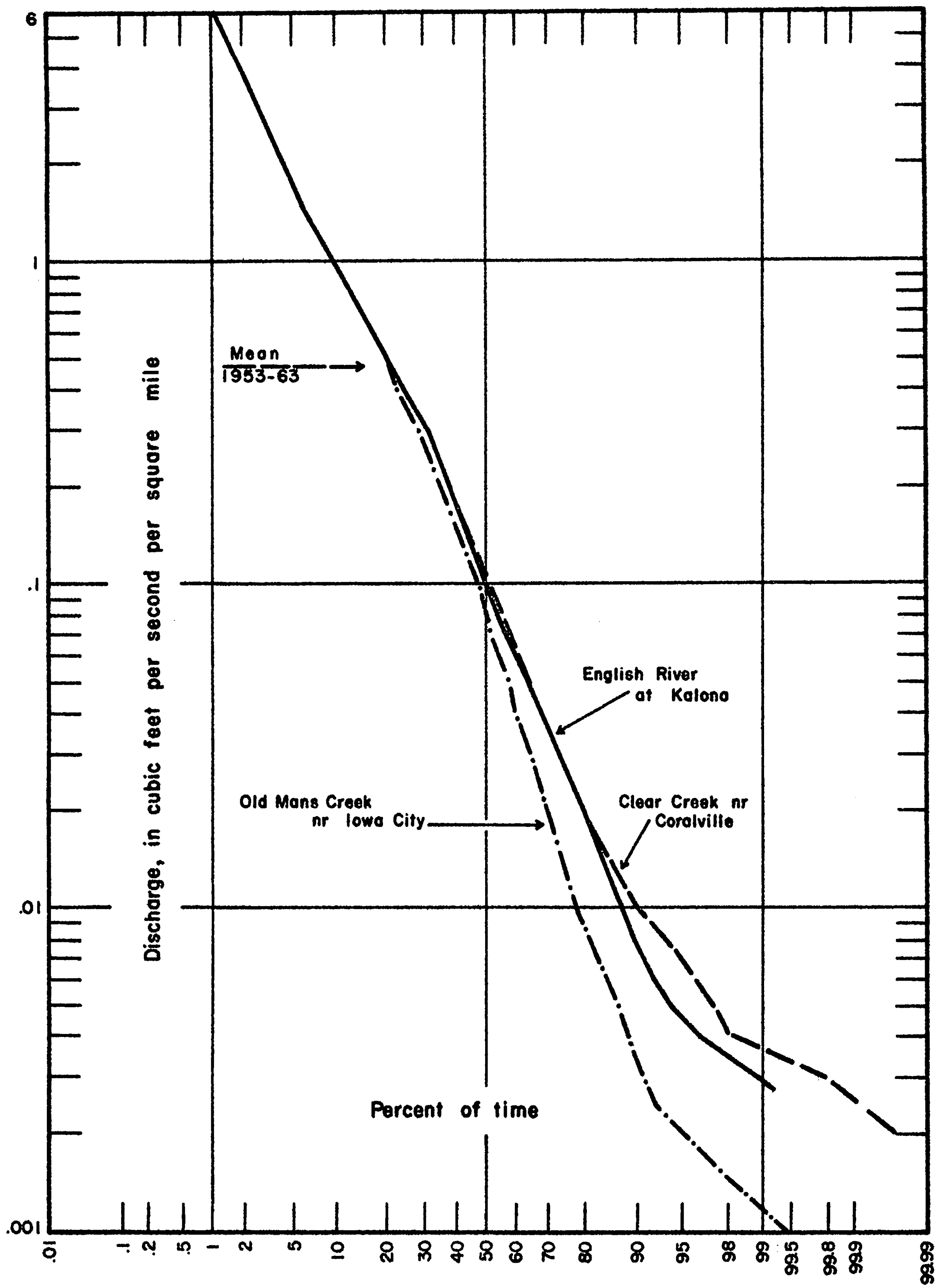

Figure 2. 1953-63 duration curves of daily flow at gaging stations in the three-basin area.

Data for plotting duration curves, for gaging stations, have been tabulated and placed with the station description in the appendix. Several time intervals have been computed including the period of record at the station, the period of record common to the three stations, the twelve-month period during which the total flow was a minimum and the April-September data for the period of record.

The curves at the three stations for the common period of 1953-63 are shown in figure 2. In order to place all three on a comparable basis the discharge at each station has been computed in cubic feet per second per square mile. The difference between the curves is apparent on the low-discharge end--the necessity for a small publication scale hides a lesser variation in the curves at the higher end.

Duration analysis for a specific period of time consolidates the flow data without regard to the distribution of the flows within the specific period. Thus, totals of extreme values may include data from several different events; this is not apparent from the presentation.

Discharge Frequency

In addition to duration information it is important to know the frequency of discharges for critical periods of varying length and for flood flows. Information on these aspects of flow are presented in the following paragraphs.

Frequency of low flow. Low flow for various periods of consecutive days have been shown for the English River gaging station. This record of 24 years can be considered long enough to provide useful estimates of the recurrence interval of low flows. These data have been tabulated and placed with the descriptive data for that station in the appendix. The shorter records for the other two stations do not presently provide sufficient record for useful frequency computations. The climatic year (April 1 to the following March 31) is used in the computations.

Minimum unregulated discharge. Frequency of minimum flows for various periods of time may stop short of showing the effects of an outstanding regime of low flows. When this regime is considerably longer than the longest period of days selected for frequency analysis it may be shown by other methods. Figures 3, 4 and 5 show one such form of presentation. Graphs are used to show enveloping curves based on low flow data that occurred in the outstanding low period in the mid 1950's. The curves indicate (1) the number of consecutive days when the average discharge was less than a selected value and (2) the number of consecutive days when the flow remained below a selected discharge.

Frequency of monthly mean flows. Frequency studies of the mean discharge for each month of the year for the English River at Kalona is shown on figure 6. The dashed lines connecting the circled points are leaders and not lines of interpolation. The plots are a series of vertical lines, with only the top point circled and shown, rather than continuous curves. They have been shown in this manner to simplify the construction and reading of the graph.

The frequency of minimum 30-day means has been indicated on the figure to show the variation of the monthly means with respect to the climatic year data. It is obvious that the 30-day minimums in the climatic year must occur during the fall and winter months. Lower average discharges are obtained for the 30-day periods of the climatic year because parts of two months may be used for computing the 30-day period.

Frequency of floods. The information on frequency of floods from the cooperative project with the Iowa Highway Research Board is shown on figure 7. The curves of this figure together with the method of use

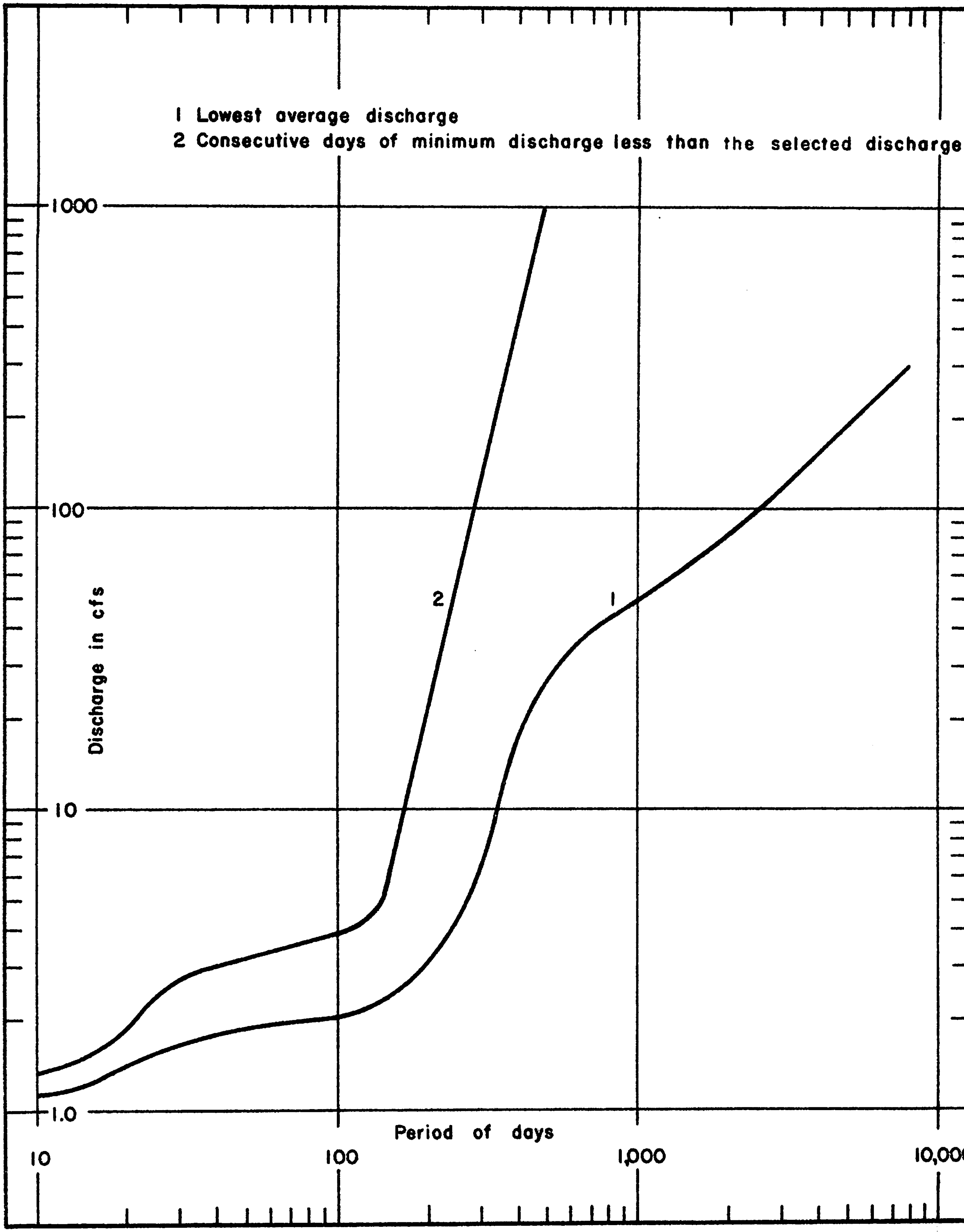

Figure 3. Enveloping curves of minimum unregulated discharge for English River at Kalona, 1940-63.

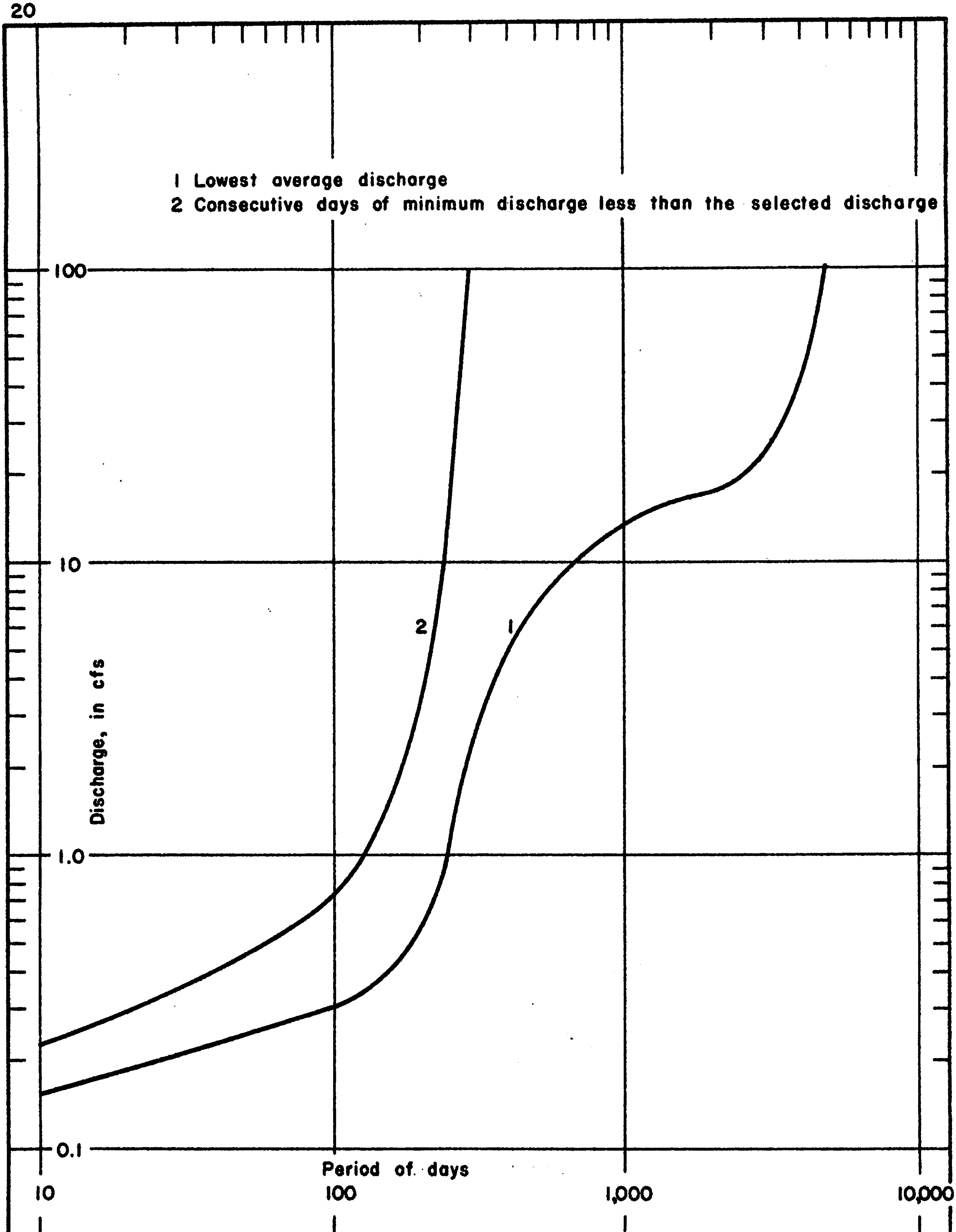

Figure 4. Enveloping curves of minimum unregulated discharge for Old Mans Creek near Iowa City, 1951-63.

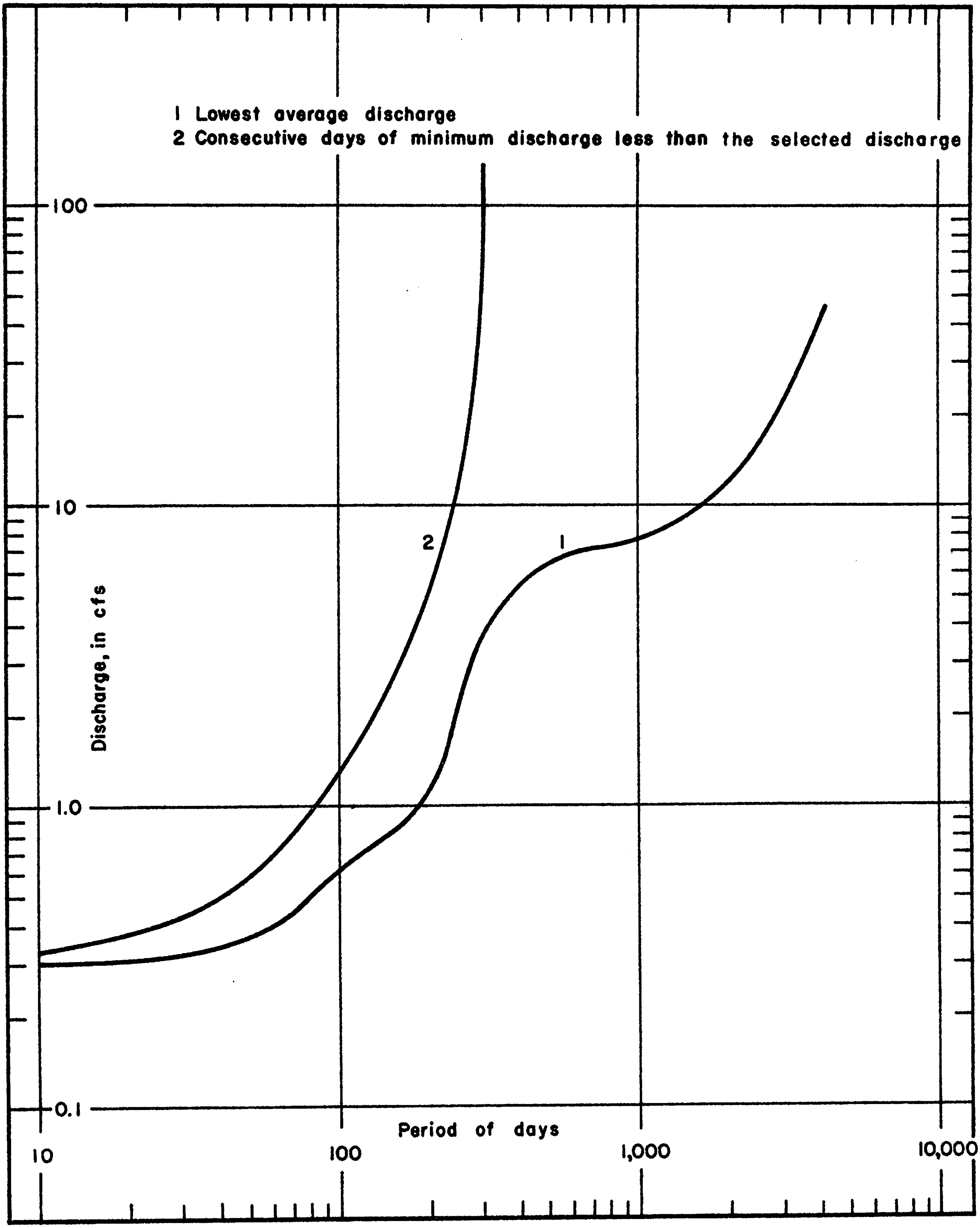

Figure 5. Enveloping curves of minimum unregulated discharge for Clear Creek near Coralville, 1952-63.

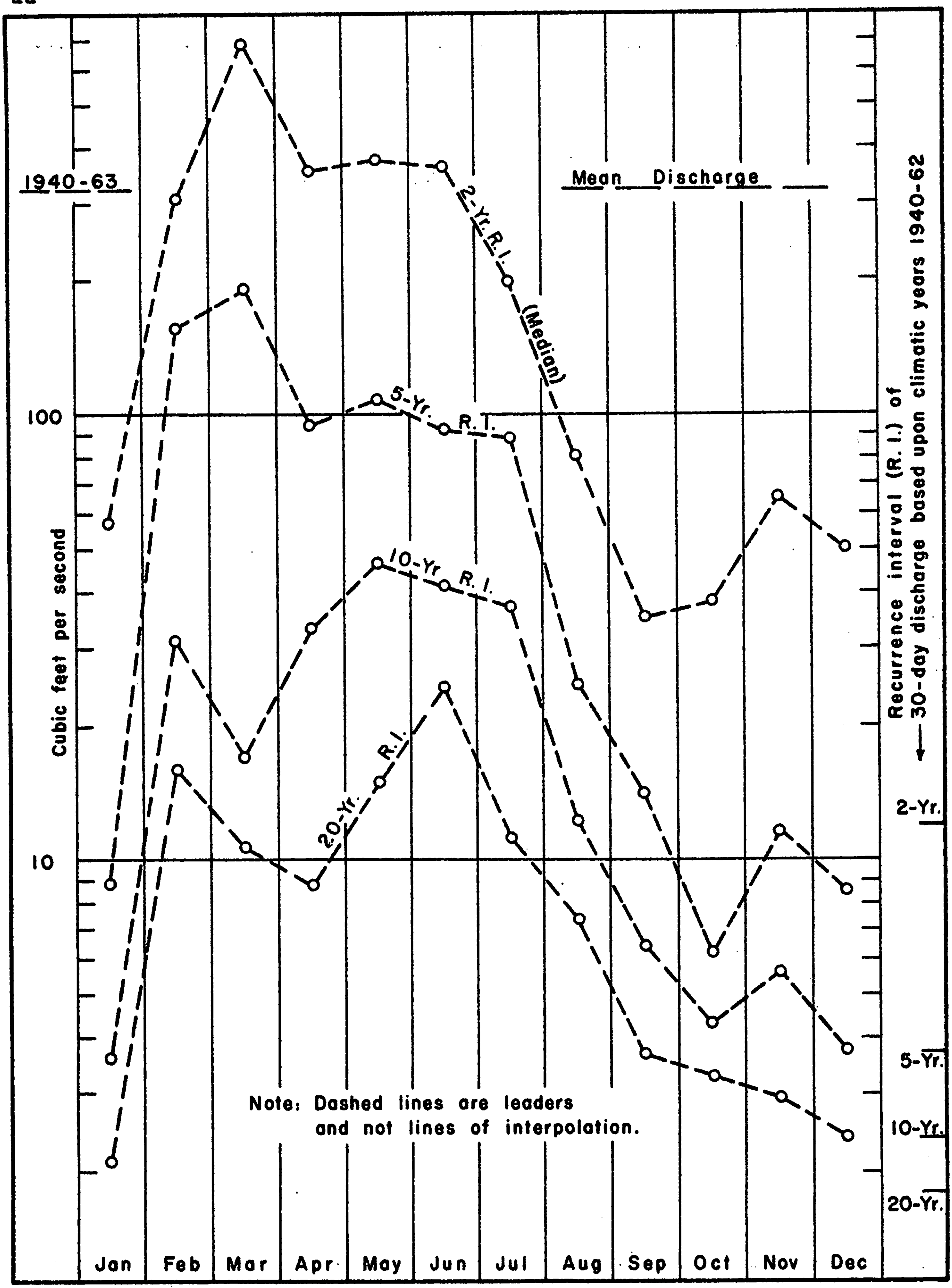

Figure 6. Frequencies of monthly mean flows, English River at Kalona.

indicated on the figure may be used to determine recurrence intervals for various floods. These may be plotted to produce a frequency curve for the selected site. Two regions are involved in the three-basin area and are referred to as A and B in this report. Region A covers that part of the English River basin lying above the confluence of the north and south forks. Region B covers the remainder of the three-basin area.

Monthly Precipitation and Runoff

Figure 8 indicates the comparison of mean monthly precipitation and runoff in the three basins for the common period 1953-63. It is apparent that the portion of the precipitation which appears as runoff in the streams is a small proportion (except in March) of that which falls. The month of March, although normally having less than half the precipitation of June and about half that of July, has a runoff of nearly 3 times that of either of these months. This results from carryover snow cover, frozen ground and lower evaporation in March contrasted with extensive cultivation (and infiltration), evaporation and vegetal growth in the summer months.

Storage

Streamflow fluctuates from day to day, with flows less than the mean about 80 percent of the time (see figure 2). Any continuous use of water from a stream is limited by the assured minimum flow unless this minimum can be augmented during periods of deficiency. Storage of higher flows can be used to increase the flow during these periods, however, the assured flow cannot exceed the mean flow of the stream less the losses which occur in storage. The amount of storage required is usually determined by studying past flows during a period or periods of significantly deficient flow.

Flood frequency curve plotting data, regions A and B							
Recurrence interval, in years	2.33	5	10	15	25	40	50
Ratio to mean annual flood	1.00	1.54	1.98	2.23	2.55	2.84	2.97

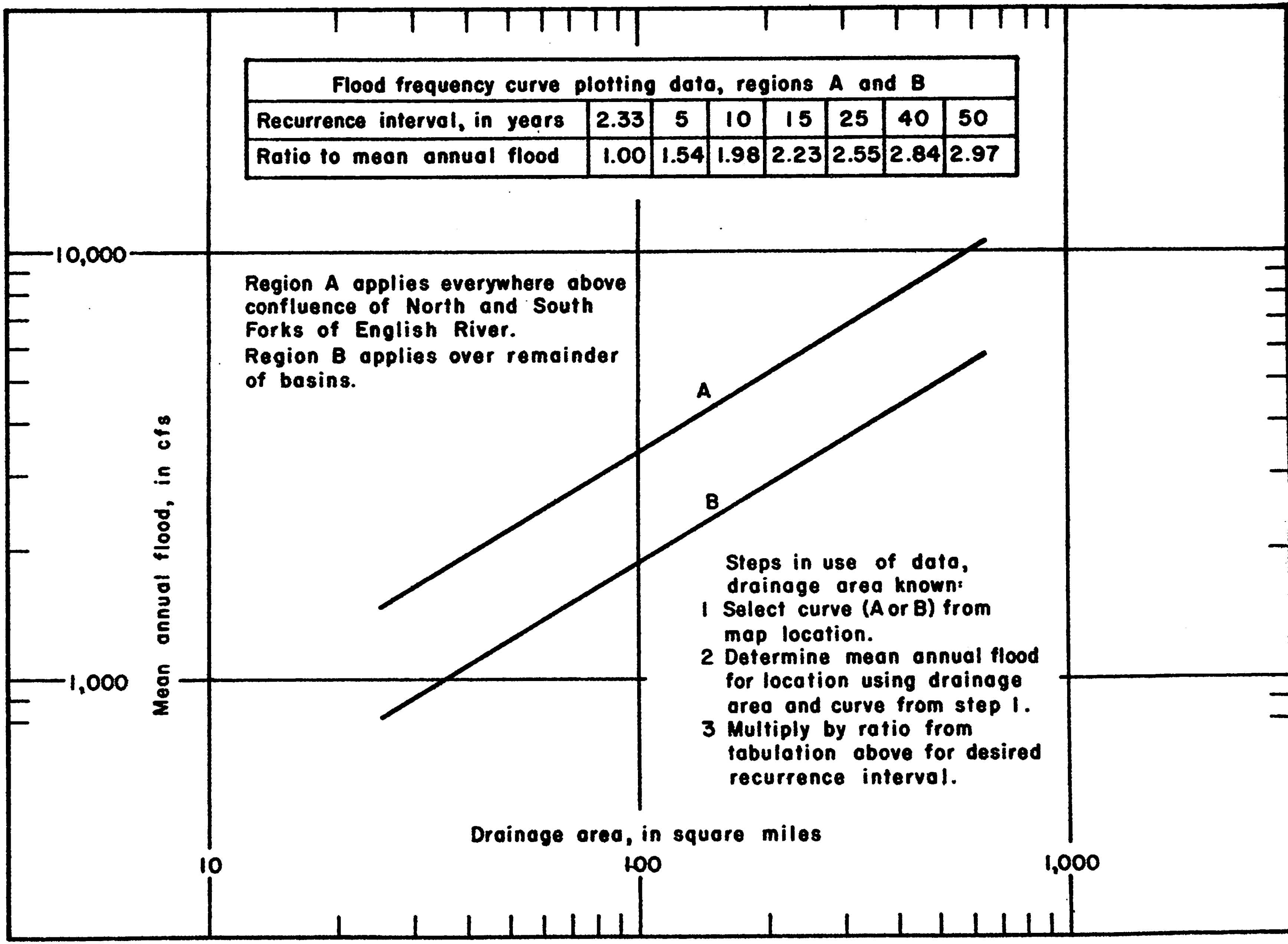

Figure 7. Frequency of floods in English River, Old Mans Creek and Clear Creek basins.

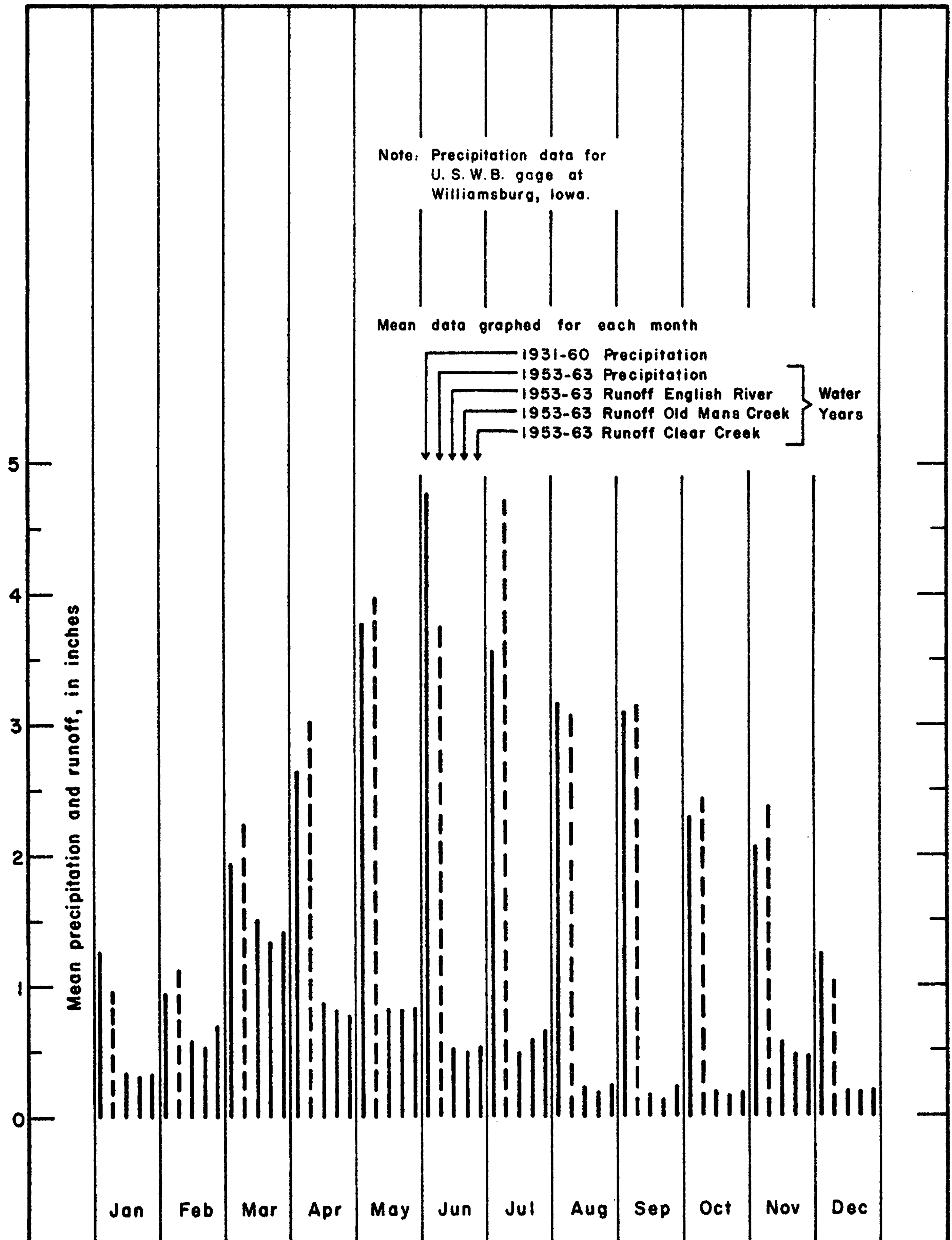

Figure 8. Mean precipitation at Williamsburg and runoff, in inches, for basins of English River, Old Mans Creek and Clear Creek.

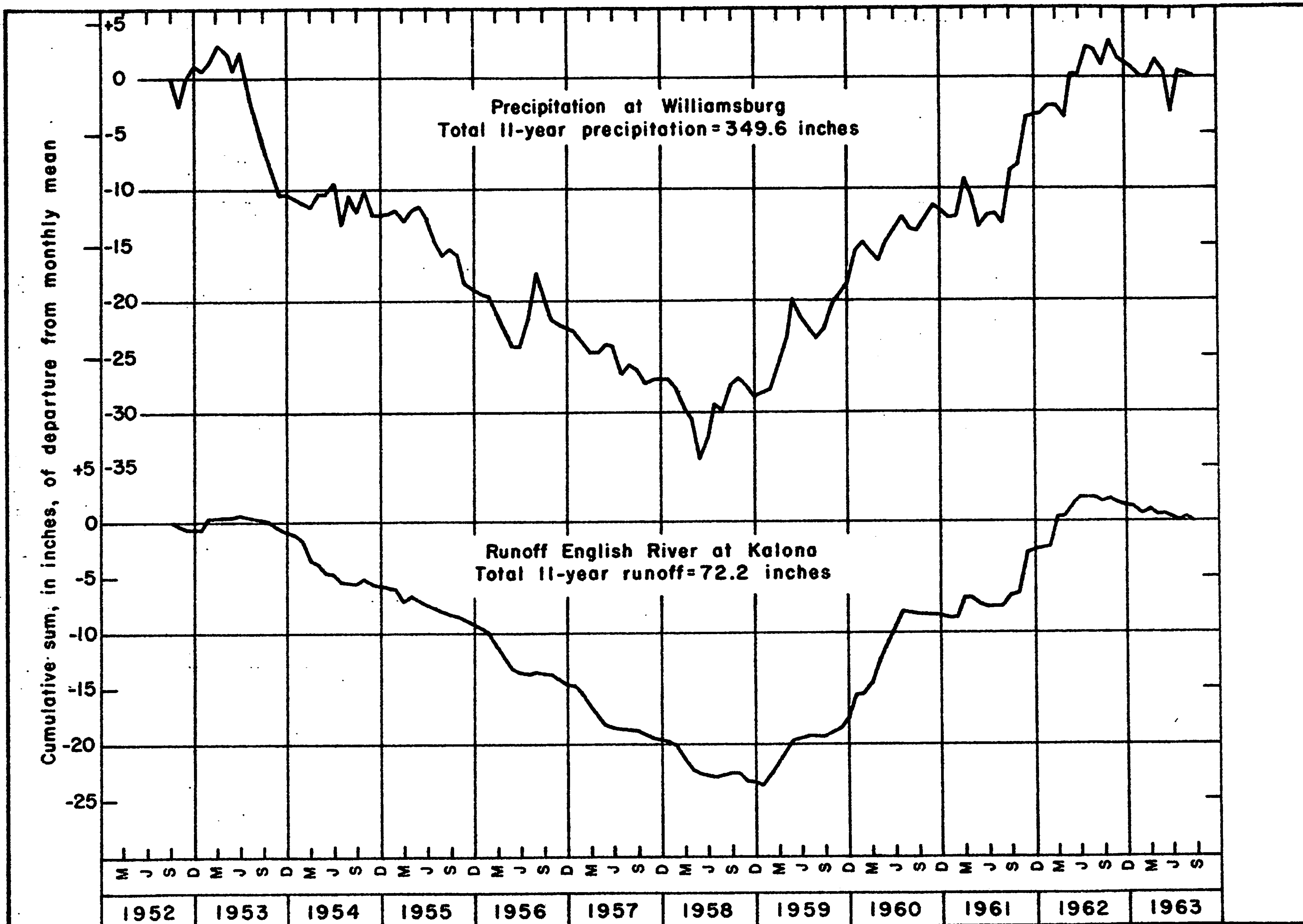

Figure 9. Cumulative departure from the monthly mean for precipitation and runoff.

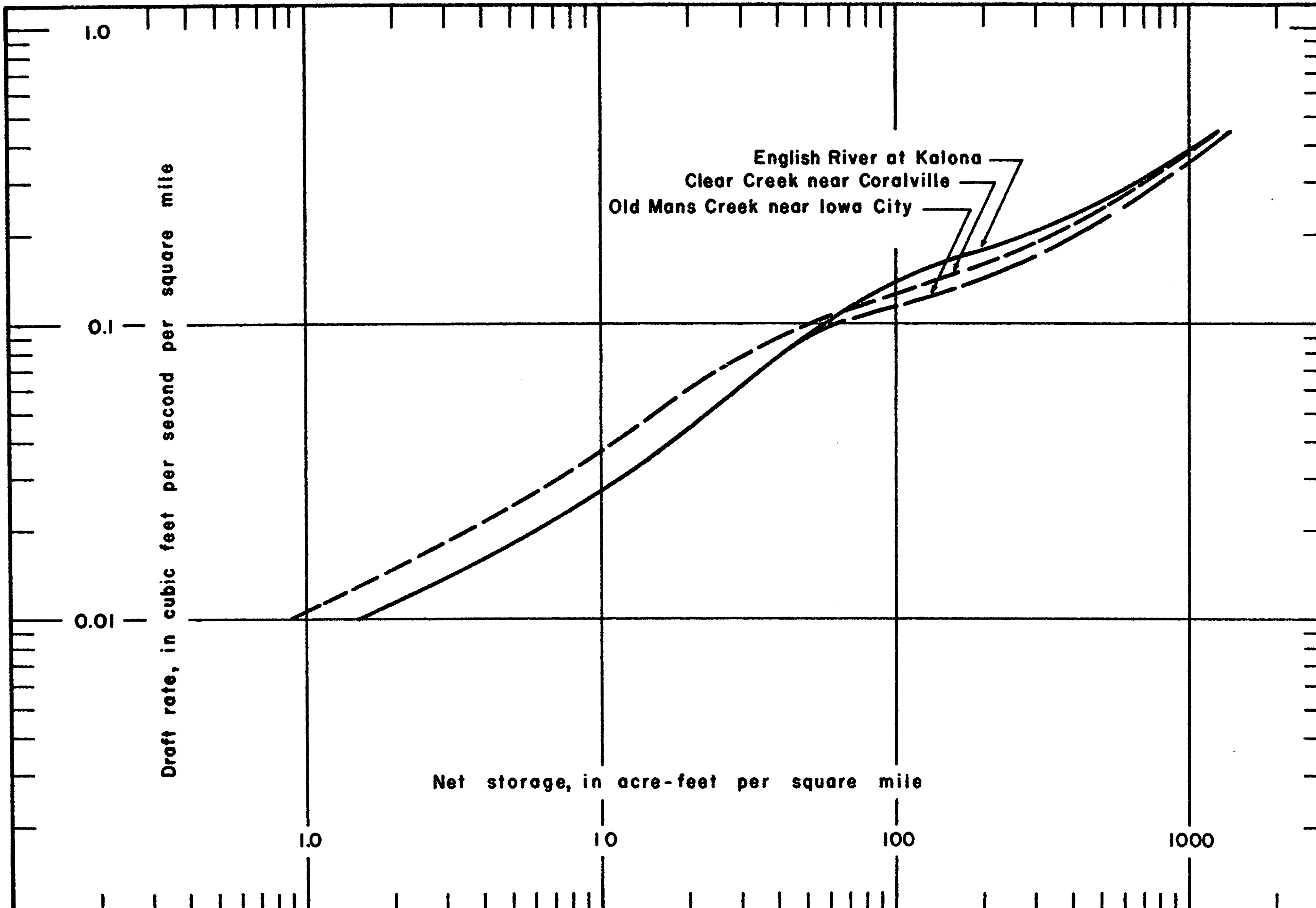

Figure 10. Low-flow draft-storage relationships for period of record at gaging stations.

The outstanding low-flow period in 1959, when streamflow reached its maximum deficiency, forms the basis of storage studies for the three gaging stations. The extent and magnitude of the period of deficient precipitation and flow is indicated by the graph of figure 9. The curves of figure 9 represent the accumulation of departures in inches from average monthly precipitation and average monthly runoff for the 1953-63 water years. These monthly figures are shown on figure 7 which also indicates the relation of the precipitation figures for the 11-year period and the Weather Bureau standard 30-year period.

The English River runoff data are shown on figure 9; graphs of the other gaging-station data are similar. At Old Mans Creek the total period runoff was 69.1 inches; deficiency began in October 1953, reached a total of 24.6 inches in January 1959, and returned to zero deficiency in July 1962. At Clear Creek the total period runoff was 71.0 inches; deficiency began in September 1953, reached a total of 24.2 inches in May 1958 and returned to zero deficiency in July 1962.

For storage requirements it is convenient to show curves of relation between the net draft rate and the storage required, as has been done in figure 10. The curves for all three stations have been placed on a comparable basis by dividing the data by the drainage area thus eliminating the drainage area as a variable. If losses applicable to a proposed reservoir are computed on a per square mile basis they may be added to the draft rate in order to arrive at gross storage.

Losses which affect a reservoir are unique for the site selected. They will include evaporation, seepage, transpiration by phreatophytes, loss of capacity through siltation and any areas of depression or other storage not useable. Evaporation (from water surfaces), normally one of the larger losses, exceeds the yearly precipitation on a reservoir. Weather Bureau records, for the 8 months of April to November (other months not published) indicate an 8-month normal evaporation of 39.1 inches for the years 1931-60 at Iowa City.

The data used to compute storage requirements are from the 1953-63 period. The low-flow for this period on nearby streams, having long records, is the lowest since 1934 or the lowest for a period of about 25 years.

Discharge Profiles

The sets of measurements made on concurrent dates at partial-record stations and supplementary sites indicate the discharge along the stream during periods of base flow. Two of these sets have been plotted against mileage for the English River, North Fork English River and South Fork English River. In addition the measurements have been correlated with concurrent daily discharge at the gaging station and between measurements along the streams. Two profiles for selected discharge at the gage have been derived from the correlations along the English and North Fork English Rivers (proportional linear interpolations can be made for intermediate flows). These are shown on the graph for figure 11. Three profiles have been computed and shown for the South Fork English on figure 12. On Old Mans and Clear Creeks the additional measurements were limited to the gage and one other location. These measurements are listed in the appendix but have not been shown graphically on profiles in this report. Similarly, measurements on other tributaries in the English basin are listed in the appendix but not shown graphically.

Correlations of discharge data using concurrent daily discharge at gaging stations and measured discharge at other sites produce curves that are a mean of the relation expressed by the individual plotted points. Thus, it must be expected that only rarely, if ever, will a series of

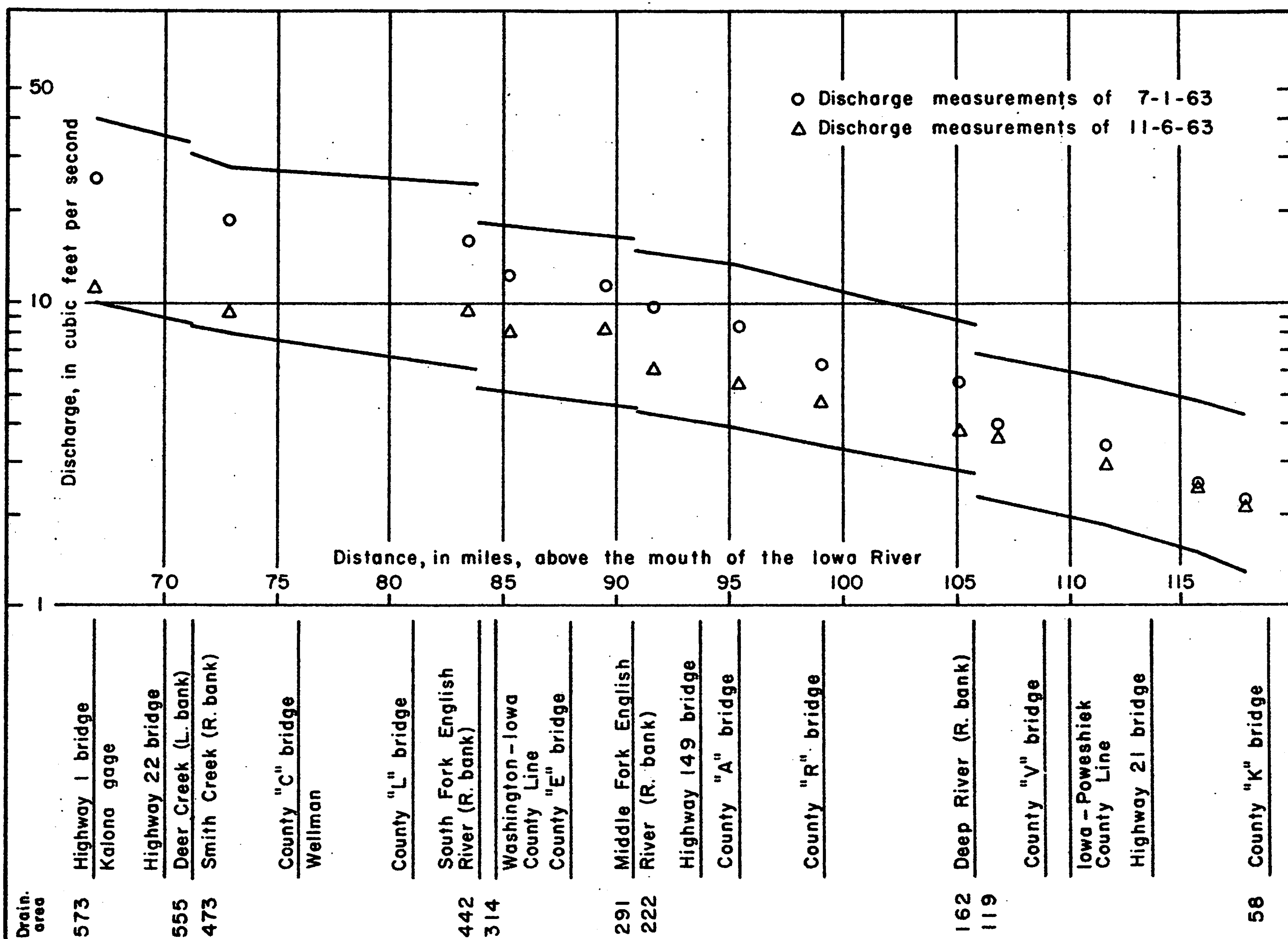

Figure 11. Low-flow discharge profiles of English and North Fork English River.

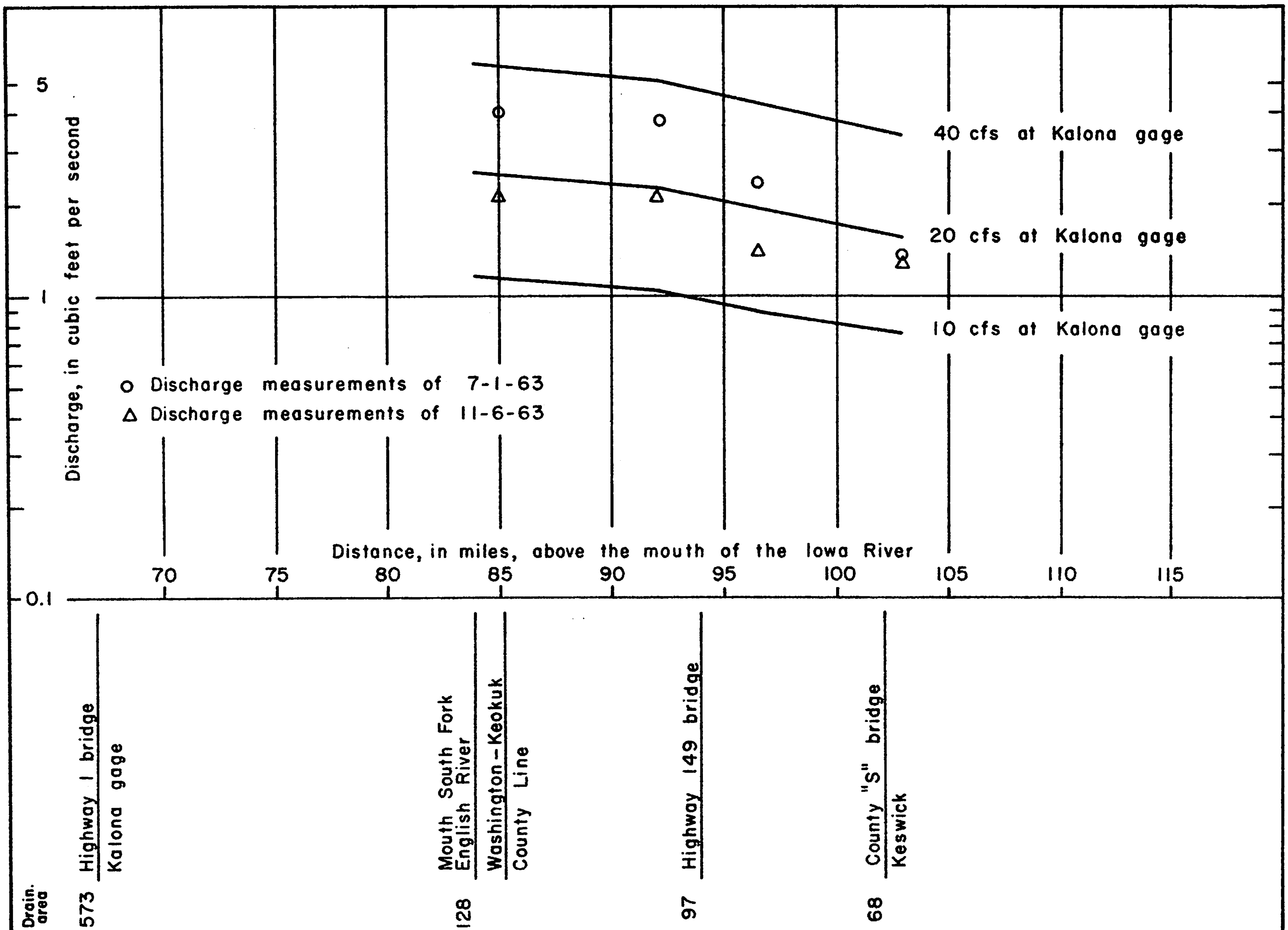

Figure 12. Low-flow discharge profiles of South Fork English River.

measurements define profiles along a stream which will coincide exactly with the profiles derived from correlations, especially for reaches of great length.

DISCUSSION OF SURFACE WATER SUPPLY

The present uses of surface water in the area are limited to recreation, dilution of wastes, and maintenance of aquatic life. The first is of minor importance since the nearby Iowa River and the Coralville Reservoir-Lake Macbride areas are large and furnish more desirable forms of water-connected recreation. Waste disposal, while relatively small in amount, is likely to pollute some reaches of the streams during periods of low flows.

Potentially the largest demand will be for supplemental irrigation. It is for regulation of this use that data on low flow is required by the Iowa Natural Resources Council. The highly variable flow and the long periods of sustained low flow of the streams (see figure 2, 3, 4, 5) limit the amount of water available for this purpose. This is particularly true for long periods of below normal precipitation when the demand will be the greatest and the supply the least. During normal years, considerable water is available during the early part of the growing season (see figures 6 and 8). To the extent that it exceeds requirements for other uses it would be available for irrigation.

While storage is physically possible and could be used to materially increase the flow during deficient periods, it would also be expensive, especially along the main stems. The wide and flat valley floors indicate a high area to storage capacity ratio. This ratio also implies a large loss potential through evaporation.

The surface water supply discussed in this report is fairly well defined at gaging stations. It is less well defined by a few measurements at partial-record and supplementary sites. Additional record at the gaging stations and more data at the other sites will result in improvement in the available knowledge.

Only streams greater than about 60 square miles in drainage area have been investigated. It is doubtful if any worthwhile information can be obtained by extrapolating those relations based upon drainage area or rates of flow in cubic feet per second per square mile in order to apply the relations to areas smaller than this minimum.

GROUND WATER*

The occurrence and availability of ground water are influenced by the formations that underlie the surface. Sand and gravel deposits, sandstones, and fissured limestones are good water-bearing formations; clays, shales and dense limestones are poor water-bearing formations.

The three-basin area is underlain by glacial drift that ranges in thickness from about 100 to 400 feet. It is thickest along the divide between Old Mans Creek and English River. The drift is predominantly clay and sandy clay that does not yield water to wells. However, lenses and stringers of sand and gravel occur haphazardly throughout the clayey drift. Where tapped by wells this sand and gravel generally yields sufficient water for most farm needs. Because of their limited extent and uncertain occurrence, test drilling should precede actual well construction.

The valleys carved into the glacial drift by streams are underlain by alluvium, which includes deposits of sand and gravel, silt, and some clay. This alluvium is permeable and may be 30 to 40 feet in thickness along the major streams. Hence, the floodplain and terrace deposits along the major

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* From the files of the cooperative investigations of the Iowa and U. S. Geological Surveys. Additional specific information can be obtained from the Iowa Geological Survey at Iowa City.

streams in the area are potentially excellent aquifers. Yields up to 100 gpm (gallons per minute) have been obtained from similar alluvial aquifiers in the lower Iowa River basin. Test drilling should always precede well construction in order to locate the thickest and most permeable deposits.

The bedrock beneath the glacial drift is shale and limestone (plate 1). Shale is the bedrock in part of English River basin and all of Clear Creek and Old Mans Creek basins, except for the extreme eastern part. The shale, ranging from 100 to over 300 feet in thickness, dips to the southwest and underlies the limestone bedrock in the English River basin.

Shales usually do not yield adequate water supplies to wells. Therefore, only in the areas where the bedrock is limestone are ground waters available at moderate depths. The limestones in the English River basin yield up to 10 gpm; those in extreme eastern Clear and Old Mans Creek basins yield up to 50 gpm.

Water-bearing limestones occur beneath the thick shale sequence throughout the three-basin area. However, the depth to these limestones is 350 to 400 feet in Clear Creek basin and 500 to 700 feet in the English River basin. Furthermore, the water from these lower limestones is highly mineralized (more than 1,000 ppm of total dissolved solids) and not usable over most of the southern half of the area.

The major deep aquifer in the three-basin area is the Jordan Sandstone, which is known to yield as much as 1,000 gpm of good-quality water to individual wells. However, this aquifer is relatively deep, 1,375 feet below land surface at Iowa City, 1,650 feet at Wellman, and 2,200 feet at Grinnell. Plate 1 shows, by contours, the elevation with respect to sea level of the top of the Jordan Sandstone throughout the three basins. To determine the depth to the Jordan at a given site in the area, add the contour value and the land-surface elevation at the site. For example, a well capable of providing 800 gpm is wanted at Williamsburg. The Jordan Sandstone is the only aquifer in the area capable of yielding this large amount of water. The depth to this aquifer can be determined by using the procedure described above. The top of the formation is estimated from Plate 1 to be about 925 feet below sea level (about midway between the -900 and -950 contours). Add to this the land surface elevation, which is about 760 feet above sea level at the C. M. St. P. & P. tracks (from Altitudes in Iowa[1/]). Thus, the depth to the top of Jordan would be about 1,685 feet at Williamsburg. Full penetration of the aquifer is necessary for maximum production. As the thickness of the aquifer averages about 60 feet in this area, the total drilling necessary to obtain 800 gpm would be about 1,745 feet.

To summarize, only small quantities of ground water are generally available from the glacial drift in the interstream areas of the three basins. Alluvial sands and gravels along the major stream courses may yield moderate amounts of water. Only in the southern part of the English basin and the extreme eastern part of the other basins can small-to-moderate quantities of water be expected from bedrock at moderate drilling depths. Large quantities of water are available from the Jordan Sandstone at depths of over 1,500 feet.

1/ Altitudes in Iowa; Iowa Geol. Survey Annual Rpt; vol. 32, p 363-550.

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______________, yearly after 1959, Surface water records of Iowa.

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Descriptions and discharge measurements at partial record and supplementary sites are shown on this and succeeding pages. Similar data as well as processed data are also shown for gaging stations. Each site or station is keyed to the map of plate 1 by means of a number shown both on the map and as a part of the description.

5-4542. Clear Creek near Oxford, Iowa
(partial-record station)

Map no.--1.

Location.--NE¼ sec.28, T.80 N., R.8 W., at bridge, 1 mile southeast of Oxford.

Miles above mouth of Iowa River.--91.5.

Drainage area.--55.0 sq mi.

Measurements

Date	Discharge (cfs)
9-23-57	0.095
4-22-58	2.19
10-06-58	2.27
10-23-59 °	5.29
8-15-60	11.1
9-05-61	1.56

5-4543. Clear Creek near Coralville, Iowa
(gaging station)

Map no.--2.

Location.--Lat 41°40'35", long 91°35'55", in $NW\frac{1}{4}SW\frac{1}{4}$ sec.6, T.79 N., R.6 W., on left bank about 50 ft upstream from highway bridge, 1.2 miles west of Coralville, and 2.2 miles upstream from mouth.

Miles above mouth of Iowa River.--80.1.

Drainage area.--98.1 sq mi.

Period of record.--October 1952 to September 1963. Monthly discharge only for some periods, published in WSP 1728.

Extremes.--Maximum discharge, 5,390 cfs May 29, 1962 (gage height, 13.31 ft); minimum daily, 0.1 cfs July 1, 1956.

Date	Discharge (cfs) Mean Daily	Date	Discharge (cfs) Mean Daily
9-23-57	0.7	10-22-59	13
4-22-58	5.3	8-15-60	15
10-06-58	5.1	9-05-61	3.7

Duration of flow

Water Years	Percent of time 1	2	5	10	20	30	40	50	60	70	80	84	90	95	98	99
1953-63	630	380	177	98	50	30	18	11	6.1	3.6	1.9	1.5	1.0	0.7	0.4	0.4
Apr.-Sept. 1953-63	480	330	170	102	54	32	20	12	7.5	4.5	2.7	2.0	1.3	0.8	0.6	0.5
Min. 12 mo.*	116	82	17	8.3	3.8	2.2	1.6	1.3	1.0	0.7	0.6	0.5	0.5	0.4	0.3	0.3

* Beginning 7/1/55.

Minimum discharges

Period of consecutive days	1	7	30	60	120	183
cfs	0.1	0.3	0.32	0.4	0.71	1.0
Starting date	7/1/56	12/15/55	12/16/53	12/8/53	10/16/55	8/19/55

5-4550.5 Old Mans Creek near Parnell, Iowa
(partial-record station)

Map no.--3.

Location:--Near southwest corner of sec.31, T.79 N., R.9 W., at bridge, 3 miles northeast of Parnell.

Miles above mouth of Iowa River.--90.7.

Drainage area.--81.2 sq mi.

Measurements

Date	Discharge (cfs)
9-25-57	0.14
4-21-58	2.57
10-22-58	9.29
10-23-59	4.27
9-06-60	1.57
9-07-61	0.99

5-4551. Old Mans Creek near Iowa City, Iowa (gaging station)

Map no.--4.

Location.--NW$\frac{1}{4}$ sec.36, T.79 N., R.7 W., at bridge, 3 miles southwest of Iowa City.

Miles above mouth of Iowa River.--69.9.

Drainage area.--201 sq mi.

Period of record.--Oct. 1950 to Sept. 1963.

Extremes.--Maximum discharge, 12,000 cfs May 29, 1962 (gage height 14.52 ft); minimum daily, 0.1 cfs Sept. 6-12, 14, 15, Oct. 1-4, 20, 21, 1957, Feb. 15-22, 1958.

Remarks.--Daily discharge records based upon fragmentary gage-height record; discharge for days of missing gage height record estimated.

Measurements

Date	Discharge (cfs)	Date	Discharge (cfs)
9-25-57	0.6	10-23-59	14
4-21-58	4.7	9-06-60	7.9
10-22-58	18	9-07-61	4.3

Duration of flow

Water Years	Percent of time 1	2	5	10	20	30	40	50	60	70	80	84	90	95	98	99
1951-63	1,250	865	425	234	119	67	39	21	9.7	4.6	1.8	1.2	0.7	0.4	0.3	0.2
Apr. - Sept. 1951-63	1,030	755	396	238	131	82	47	28	16	7.8	4.2	3.1	1.3	0.7	0.4	0.3
1953-63	1,260	820	370	192	97	53	31	16	7.6	4.1	1.6	1.2	0.7	0.4	0.3	0.2
Min. 12 months*	120	68	19	6.7	2.9	1.8	1.1	0.7	0.5	0.4	0.4	0.4	0.3	a	a	a

* Beginning 7/01/55.
a Daily discharge was 0.2 cfs or greater 100% of the time.

5-4551. Old Mans Creek near Iowa City, Iowa--Continued

Minimum discharges

Period of consecutive days	1	7	30	60	120	183
cfs	0.1	0.1	0.21	0.26	0.33	0.49
Starting date	9/06/57	9/06/57	9/28/57	9/05/57	10/11/55	8/14/55

North Fork English River above Guernsey, Iowa
(supplemental measuring site)

Map no.--5.

Location.--SE$\frac{1}{4}$ sec.14, T.79 N., R.14 W., at bridge, 4.5 miles west of Guernsey.

Miles above mouth of Iowa River.--117.9.

Drainage area.--61.0 sq mi.

Measurements

Date	Discharge (cfs)
4-15-63	8.60
7-01-63	2.21
11-06-63	2.13

5-4552. North Fork English River near Guernsey, Iowa
(partial-record station)

Map no.--6.

Location.--Near southwest corner of sec.17, T.79 N., R.13 W., at bridge, 2$\frac{1}{4}$ miles west of Guernsey.

Miles above mouth of Iowa River.--115.8.

Drainage area.--68.7 sq mi.

Measurements

Date	Discharge (cfs)
9-18-57	5.44
4-22-58	10.0
10-03-58	9.94
10-21-59	5.28
9-06-60	4.11
9-06-61	10.1
4-15-63	8.75
7-01-63	2.45
11-06-63	2.58

North Fork English River below Guernsey, Iowa
(supplemental measuring site)

Map no.--7.

Location.--Center sec.23, T.79 N., R.13 W., at bridge, 1 mile southwest of Guernsey.

Miles above mouth of Iowa River.--111.7.

Drainage area.--88.9 sq mi.

Measurements

Date	Discharge (cfs)
4-15-63	11.4
7-01-63	3.39
11-06-63	2.92

North Fork English River near Deep River, Iowa
(supplemental measuring site)

Map no.--8

Location.--NW$\frac{1}{4}$ sec.33, T.79 N., R.12 W., at bridge, 6 miles northeast of Deep River.

Miles above mouth of Iowa River.--106.85.

Drainage area.--117 sq mi.

Measurements

Date	Discharge (cfs)
4-15-63	12.8
7-01-63	3.98
11-06-63	3.67

Deep River near Deep River, Iowa
(supplemental measuring site)

Map no.--9.

Location.--East line sec.5, T.78 N., R.12 W., at bridge, 6 miles east of Deep River.

Miles above mouth of Iowa River.--106.35.

Drainage area.--42.7 sq mi.

Measurements

Date	Discharge (cfs)
4-15-63	4.19
7-01-63	.58
11-06-63	.74

North Fork English River below Deep River near Deep River, Iowa
(supplemental measuring site)

Map no.--10.

Location.--NE$\frac{1}{4}$ sec.4, T.78 N., R.12 W., at bridge, 6.5 miles northeast of Deep River.

Miles above mouth of Iowa River.--105.2.

Drainage area.--163 sq mi.

Measurements

Date	Discharge (cfs)
4-15-63	18.9
7-01-63	5.52
11-06-63	3.80

North Fork English River near Millersburg, Iowa
(supplemental measuring site)

Map no.--11.

Location.--South line sec.32, T.79 N., R.11 W., at bridge, 2 miles north of Millersburg.

Miles above mouth of Iowa River.--99.15.

Drainage area.--178 sq mi.

Measurements

Date	Discharge (cfs)
4-16-63	23.9
7-01-63	6.30
11-06-63	4.74

North Fork English River near Parnell, Iowa
(supplemental measuring site)

Map no.--12.

Location.--West line sec.1, T.78 N., R.11 W., at bridge, 4 miles west of Parnell.

Miles above mouth of Iowa River.--95.3.

Drainage area.--210 sq mi.

Measurements

Date	Discharge (cfs)
4-16-63	29.3
6-26-63	8.52
7-01-63	8.44
11-06-63	5.50

5-4552.5 North Fork English River near North English, Iowa
(partial-record station)

Map no.--13.

Location.--Near southwest corner sec.17, T.78 N., R.10 W., at bridge, 3½ miles northeast of North English.

Miles above mouth of Iowa River.--91.75.

Drainage area.--221 sq mi.

Measurements

Date	Discharge (cfs)
9-25-57	8.47
4-21-58	23.3
10-22-58	38.0
10-22-59	30.0
9-06-60	9.46
9-07-61	16.7
4-16-63	31.8
6-26-63	9.78
7-01-63	9.78
11-06-63	6.17

5-4552.6 Middle Fork English River near North English, Iowa
(partial record station)

Map no.--14.

Location.--Near northeast corner sec.25, T.78 N., R.11 W., at bridge, 2 miles northeast of North English.

Miles above mouth of Iowa River.--92.3.

Drainage area.--66.7 sq mi.

Measurements

Date	Discharge (cfs)
9-25-57	0.16
4-21-58	2.69
10-22-58	0.87
10-22-59	3.40
9-06-60	.52
9-07-61	0
4-16-63	7.58
6-26-63	1.40
7-01-63	.80
11-06-63	1.36

North Fork English River below Middle Fork English River
near North English, Iowa
(supplemental measuring site)

Map no.--15.

Location.--NW$\frac{1}{4}$ sec.28, T.78 N., R.10 W., at bridge, 3.5 miles northeast of North English.

Miles above mouth of Iowa River.--89.5.

Drainage area.--296 sq mi.

Measurements

Date	Discharge (cfs)
4-16-63	37.0
6-26-63	12.3
7-01-63	11.5
11-06-63	8.22

North Fork English River above South Fork English River
near North English, Iowa
(supplemental measuring site)

Map no.--16.

Location.--West line sec.31, T.78 N., R.9 W., at bridge, 6.5 miles east of North English.

Miles above mouth of Iowa River.--85.3.

Drainage area.--310 sq mi.

Measurements

Date	Discharge (cfs)
4-16-63	39.4
6-26-63	12.8
7-01-63	12.2
11-06-63	8.07

5-4554. South Fork English River near Keswick, Iowa
(partial-record station)

Map no.--17.

Location.--SW$\frac{1}{4}$ sec.16, T.77 N., R.12 W., at bridge, 1$\frac{1}{2}$ miles northwest of Keswick.

Miles above mouth of Iowa River.--103.05.

Drainage area.--66.2 sq mi.

Measurements

Date	Discharge (cfs)
9-17-57	1.55
10-03-58	1.66
10-22-59	7.03
9-06-60	2.03
9-07-61	3.47
4-15-63	5.58
7-01-63	1.33
11-06-63	1.30

South Fork English River near Webster, Iowa
(supplemental measuring site)

Map no.--18.

Location.--NE$\frac{1}{4}$ sec.20, T.77 N., R.11 W., at bridge, about 2 miles northeast of Webster.

Miles above mouth of Iowa River.--96.55.

Drainage area.--88.5 sq mi.

Measurements

Date	Discharge (cfs)
4-16-63	9.47
7-01-63	2.34
11-06-63	1.40

South Fork English River near South English, Iowa
(supplemental measuring site)

Map no.--19.

Location.--NE$\frac{1}{4}$ sec.13, T.77 N., R.11 W., at bridge, 2.5 miles northeast of South English.

Miles above mouth of Iowa River.--92.2.

Drainage area.--101 sq mi.

Measurements

Date	Discharge (cfs)
4-16-63	12.6
7-01-63	3.76
11-06-63	2.15

5-4554.5 South Fork English River near Kinross, Iowa (partial-record station)

Map no.--20.

Location.--NW$\frac{1}{4}$ sec.7, T.77 N., R.9 W., at bridge, 3 miles northeast of Kinross.

Miles above mouth of Iowa River.--85.05.

Drainage area.--125 sq mi.

Measurements

Date	Discharge (cfs)
9-25-57	5.68
4-22-58	7.20
10-03-58	1.64
10-22-59	11.0
9-06-60	3.23
9-07-61	5.76
4-16-63	15.3
6-26-63	4.34
7-01-63	4.05
11-06-63	2.13

English River below South Fork English River near Kinross, Iowa (supplemental measurement site)

Map no.--21.

Location.--W$\frac{1}{2}$ sec.5, T.77 N., R.9 W., at bridge, 4.5 miles northeast of Kinross.

Miles above mouth of Iowa River.--83.4.

Drainage area.--449 sq mi.

Measurements

Date	Discharge (cfs)
4-16-63	58.3
6-26-63	17.1
7-01-63	16.1
11-06-63	9.58

English River near Wellman, Iowa
(supplemental measuring site)

Map no.--22.

Location.--S½ sec.8, T.77 N., R.8 W., at bridge, 2 miles northeast of Wellman.

Miles above mouth of Iowa River.--72.85.

Drainage area.--472 sq mi.

Measurements

Date	Discharge (cfs)
4-16-63	62.4
7-01-63	18.9
11-06-63	9.37

Smith Creek near Kalona, Iowa
(supplemental measuring site)

Map no.--23.

Location.--NE¼ sec.16, T.77 N., R.8 W., at bridge, 3.5 miles west of Kalona.

Miles above mouth of Iowa River.--72.25.

Drainage area.--40.4 sq mi.

Measurements

Date	Discharge (cfs)
4-16-63	5.33
7-01-63	0.42
11-06-63	0.27

Deer Creek near Kalona, Iowa
(supplemental measuring site)

Map no.--24.

Location.--NW$\frac{1}{4}$ sec.10, T.77 N., R.8 W., at bridge, 3 miles northwest of Kalona.

Miles above mouth of Iowa River.--71.25.

Drainage area.--39.2 sq mi.

Measurements

Date	Discharge (cfs)
4-16-63	6.63
7-01-63	1.14
11-06-63	.049

5-4555. English River at Kalona, Iowa (gaging station)

Map no.--25.

Location.--Lat 41°28'10", long 91°43'00", in SE¼SE¼ sec.13, T.77 N., R.8 W., on right bank, 30 ft upstream from bridge on State Highway 1, 1 mile south of Kalona, 4.5 miles downstream from Smith Creek, and 14.5 miles upstream from mouth.

Miles above mouth of Iowa River.--67.

Drainage area.--573 sq mi.

Period of record.--Sept. 1939 to Sept. 1963.

Extremes.--Maximum discharge, 18,500 cfs Mar. 31, 1960, (gage height 19.89 ft); minimum daily, 1.1 cfs Jan. 20-27, 1956.

Discharge (cfs) Date	Mean daily	Discharge (cfs) Date	Mean daily	Discharge (cfs) Date	Mean daily
9-17-57	28	10-22-58	50	4-15-63	93
9-18-57	19	10-21-59	68	4-16-63	95
9-25-57	21	10-22-59	65	6-26-63	28
4-21-58	49	9-06-60	26	7-01-63	25.5
4-22-58	49	9-06-61	42	11-06-63	11.4
10-03-58	33	9-07-61	34		

Duration of flow

Water Years	Percent of time 1	2	5	10	20	30	40	50	60	70	80	84	90	95	98	99
1940-63	3,850	2,640	1,380	730	363	216	135	79	49	29	15	11	6.5	3.7	2.5	2.1
Apr.-Sept.1940-63	3,700	2,700	1,480	810	425	255	156	100	66	42	24	18	11	6.0	3.2	2.6
1953-63	3,700	2,350	1,130	600	295	176	100	59	35	21	11	8.3	4.5	2.7	2.1	1.7
Min. 12 months*	270	190	60	22	12	8.3	5.3	3.5	2.8	2.5	2.1	2.0	1.7	1.5	1.2	a

* Beginning 7/01/55.

a Daily discharge was 1.1 cfs or greater 100% of time.

Minimum discharges

Period of consecutive days	1	7	30	60	120	183
cfs	1.1	1.1	1.65	1.94	2.16	2.85
Starting date	1/20/56	1/20/56	1/11/56	12/10/55	10/16/55	8/14/55

Low-flow frequency

Period of days	Recurrence interval, years			
	2	5	10	20
7	9.7	2.8	1.7	1.3
30	12	3.7	2.4	1.8
60	23	5.9	3.0	2.1
120	43	10	4.1	2.4