ESTIMATES OF LONG-TERM SUSPENDED-SEDIMENT LOADS IN BAY CREEK AT NEBO, PIKE COUNTY, ILLINOIS, 1940-80

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DEFINITION OF TERMS

Annual mean is the arithmetic mean of all the values for a single year of record.

Daily mean is the mean value for a single day.

Discharge is the mass or volume of material passing a stream transect in a unit of time. It is a rate and usually is expressed in terms of mass or volume per unit time (tons per day, cubic feet per second).

Mean annual is the arithmetic mean of the annual means for all the years of record, or for a specific number of years.

Mean daily is the arithmetic mean of the daily means for a specific date for all the years of record, or for a specific number of years.

Mean monthly is the arithmetic mean of all the monthly means for a specific month for all the years of record, or for a specific number of years.

Monthly mean is the arithmetic mean of the individual daily mean values during a month.

Sediment load is the mass of sediment in suspension and(or) in transport. It is usually measured in tons.

Sediment yield is a measurement of sediment load per unit area. It is usually measured in tons per square mile for a specific time period.

Suspended sediment is the portion of the sediment that is carried in suspension by the turbulent components of streamflow.

Suspended-sediment concentration is the mass of suspended sediment per unit volume of water. It is usually measured in milligrams per liter.

Transport equation is a relation between suspended-sediment discharge and water discharge used to estimate suspended-sediment discharges.

Water year is the period from October 1 of a given year to September 30 of the following year. The number of the year is the year in which it ends (the year beginning October 1, 1979, and ending September 30, 1980, is the 1980 water year).

CONVERSION FACTORS AND ABBREVIATIONS

The following factors may be used to convert the inch-pound units published herein to the International System of Units (SI). These factors are shown to four significant figures, but the conventional SI system equivalents should be consistent with the values in the inch-pound system.

Multiply inch-pound units	By	To obtain SI units
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	4,047	square meter (m^2)
	0.4047	hectare
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
ton, short	0.9072	megagram (Mg)
	Temperature	
degree Fahrenheit (°F)	°C = 5/9 (°F-32)	degree Celsius (°C)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

LONG-TERM SUSPENDED-SEDIMENT LOADS IN BAY CREEK AT NEBO, PIKE COUNTY, ILLINOIS, 1940-80

By Timothy R. Lazaro, Kathleen K. Fitzgerald, and Leonard R. Frost, Jr.

ABSTRACT

Streamflow data for Bay Creek at Nebo, Illinois, have been collected since 1940, and suspended-sediment concentrations have been collected intermittently since 1966. Five years of daily suspended-sediment discharges (1968, 1969, 1975, 1976, and 1980), computed from once- or twice-weekly samples (more often during storm events), were used to develop transport equations that can be used to estimate long-term suspended-sediment discharges from long-term water-discharge records.

Discharge was divided into three groups based on changes in slope on a graph of the logarithms of water discharge versus suspended-sediment discharge. Two subgroups were formed within each of the three groups by determining whether the flow was steady or increasing, or was decreasing. Seasonality was accounted for by introducing day of the year as sine and cosine functions.

The suspended-sediment load estimated from the equations for the 5 years of daily suspended-sediment records was 77.3 percent of that computed from daily sediment- and water-discharge records for those years. The mean annual suspended-sediment load for 41 years of estimated loads was 359,500 tons, which represents a yield of about 3.5 tons per acre from the Bay Creek drainage basin.

INTRODUCTION

The Great River Study was authorized by Congress in the Water Resources Development Act of 1976 (PL 94-587) in response to public concern for the environmental quality of the upper Mississippi River. The purpose of the study was to develop a river system management plan for the upper part of the river from the head of navigation in Minneapolis, Minnesota, southward to Cairo, Illinois. Three Great River Environmental Action Teams (GREAT) were to study separate reaches of the river.

Bay Creek, in Pike County, Illinois, (fig. 1) is in the GREAT III study reach that extends from Saverton, Missouri, southward to Cairo, Illinois. Bay Creek was the only stream in the Illinois part of the GREAT III study reach for which any agency had both sediment concentration and streamflow data.

The Corps of Engineers, Rock Island District, has collected samples for suspended-sediment concentrations at the U.S. Geological Survey gaging station at Nebo since October 1965 (1966 water year). An analysis of the sediment concentrations and streamflow records was needed to provide the GREAT III study team with some information for evaluating sediment transport to the Mississippi River by the small tributary streams in Illinois.

The objective of this study was to estimate long-term suspended-sediment discharge past the gaging station on Bay Creek at Nebo using the long-term water-discharge records for the period 1940-80 and the suspended-sediment concentrations for water years 1966-80. This report presents estimates of suspended sediment transported by Bay Creek and describes the procedures used to make the estimates. The work was done in cooperation with the Erosion and Sedimentation Work Group of the GREAT III study team and with the U.S. Army Corps of Engineers, St. Louis District. The Rock Island District provided the historical records of sediment concentrations.

LOCATION AND DESCRIPTION OF STUDY AREA

Bay Creek is located in Pike County in western Illinois (fig. 2). The drainage area of the watershed is 176 mi^2 at Illinois Highway 96 where it becomes Bay Creek Diversion Ditch. The drainage area upstream from the gaging station at Nebo is 161 mi^2. A second gaging station on Bay Creek, with a drainage area of 34 mi^2, is located at Pittsfield.

Upstream from Nebo the watershed is in the Lincoln Hills Section of the Ozark Plateau Province (Leighton, Ekblaw, and Horberg, 1948). Downstream from Highway 96, Bay Creek Diversion Ditch crosses the flood plain of the Mississippi River, joins Sixmile Creek Diversion Ditch, and thence flows to the Mississippi River in Calhoun County at mile 273. Because of the abrupt changes in topography and physiography from the bluffs area to the flood-plain area, the sediment transport characteristics at Nebo should not be extended to the entire watershed.

Soils in the watershed upstream from Nebo are predominantly silt-loams and most of the land is in corn and soybean production. From 1940 to 1978, in Pike County, the number of farms decreased from 2,836 to 1,434 and the average farm size more than doubled, from 167 to 335 acres. The resulting increase in total acreage cultivated was 1.6 percent (U.S. Department of Commerce, Bureau of Census, 1940-78).

The climate in the basin is typically continental. Warm summers, cold winters, and frequent short-term fluctuations in temperature, humidity, cloud cover, and wind direction are characteristic (U.S. Department of Commerce, 1951-60). The mean annual temperature was 53.2°F for the period from 1951 to 1979 at Griggsville, Illinois (15 miles north of Nebo). For the same period, the mean temperatures for the coldest month (January) and the warmest month (July) were 29.3°F and 76.7°F, respectively (U.S. Department of Commerce, 1951-80).

Annual precipitation averaged 37.93 inches during the period from 1941 to 1975, when precipitation records were discontinued, at Pleasant Hill, Illinois (4 miles west of Nebo). Mean monthly precipitation varied from a low of 1.55 inches for January to a high of 4.80 inches for June during the period from 1941 to 1975. Annual precipitation for the 5 years for which sediment discharge data were used in this study ranged from 25.95 to 46.89 inches (U.S. Department of Commerce, 1931-60, 1951-60, 1951-80). Precipitation records for 1976 to 1980 are from Griggsville, Illinois. A plot of precipitation records from both stations showed the records to be equivalent.

The slope of Bay Creek is relatively uniform at 5.7 ft/mi on the main channel above Nebo. Tributary streams characteristically have steeper slopes than the main channel. Cold Run, Buckeye Creek, and Honey Creek (fig. 2) have slopes of 37.1, 35.7, and 24.3 ft/mi, respectively. Topographic relief in the watershed above Nebo is about 420 feet with altitudes ranging from 860 feet in the headwater areas to 440 feet at the gaging station near Nebo.

METHODS

The relation between sediment discharge and water discharge is commonly used to estimate long-term sediment discharge when short-term sediment records are available at stations with long-term records of water discharge (Colby, 1956). The relations are usually determined between the logarithms of water discharge in cubic feet per second and sediment discharge in tons per day.

Many factors affect the accuracy of the estimates. Among the basic assumptions are that (1) water discharge during the short-term period is representative of the long term, (2) the availability of sediment particles for transport was the same for the long term as for the short term, and (3) the seasonal variations in the availability of sediment for transport are minimal or that variations can be accounted for.

The U.S. Army Corps of Engineers, Rock Island District, has operated a suspended-sediment sampling station on Bay Creek at Nebo since 1966. Samples were collected once or twice per week and more often during storm events from the upstream side of the bridge at a single, fixed location using a depth-integrating suspended-sediment sampler. As a part of this study, four additional samples were collected at multiple verticals in the cross section using the equal-width increment-sampling method (Porterfield, 1977). Mean concentrations for the cross section were determined from these measurements and were used to determine a coefficient for the fixed location. The ratios of the multivertical to single-vertical, fixed location concentrations ranged from 0.92 to 1.04 and, therefore, a coefficient of 1.0 was used for the fixed location.

Five years (1968, 1969, 1975, 1976, and 1980) had the best sample record and, therefore, daily suspended-sediment discharges were computed for these water years. Annual precipitation ranged from 25.95 to 46.89 inches during these years. The mean annual precipitation during the period 1941 to 1975 was 37.93 inches at Pleasant Hill, Illinois (U.S. Department of Commerce, 1931-60, 1951-60, 1951-80). A graph of cumulative precipitation, in inches, versus year (fig. 3) shows a fairly even distribution of precipitation over the years except for two relatively dry years in the early 1950's. Mean daily discharge for the 5 years for which sediment records were computed was 97.4 ft^3/s compared to a mean of 96.1 ft^3/s for the period of record (1940-80). A graph of cumulative runoff versus cumulative precipitation (fig. 4) shows a change in the rainfall-runoff relation after the dry years of the early 1950's. The relation was most different from the early years of record during the 1951 to 1955 period and by 1966 gradually returned to what it had been prior to 1951. These changes could have resulted from land use changes and may also have affected the suspended-sediment discharge.

Particle-size analyses were made on two samples of bed material (table 1) collected in 1980, and 66 samples of suspended sediment (table 2) collected during the period 1951 to 1980. The analyses of bed material show that the streambed consists principally of silt- and clay-size (<0.062 mm) material and that the stream does transport this material over a wide range of water discharge. The suspended-sediment analyses suggest that the percentage of clay-size (<0.004 mm) material being transported may have increased during the period of record. Some changes in material made available for erosion should be consistent with changes in agricultural practices attendant to the reduction in number of farms and increase in farm size and the increase in the total acreage cultivated.

The daily suspended-sediment discharge records that were computed for water years 1968, 1969, 1975, 1976, and 1980, and for 12 additional days during other years of record when water discharges were high and suspended-sediment discharges were available, were used to develop transport equations that can be used to estimate sediment discharge from streamflow records. A graph showing plots of the logarithms of water discharge versus sediment discharge (fig. 5) showed apparent changes in slope at 63 (log = 1.80) and 367 (log = 2.56) ft^3/s. The streamflow data (Qm) were divided into three groups: $Qm<63$, $63<Qm<367$, and $Qm>367$. The change (Qc) in Qm was then calculated by subtracting the discharge of the previous day to determine whether the discharge was steady, increasing, or was decreasing. Each of the previous three groups was then divided into two subgroups: $Qc>0$ and $Qc<0$. A flow chart of this procedure is shown in figure 6.

Regression analysis was used to develop transport equations for each of the six groups; these equations were used to estimate daily suspended-sediment discharge from daily mean water-discharge records for the 1940 through 1980 water years. Suspended-sediment discharge varies with season as shown in figure 7. Colby (1956) observed that for a given rate of flow in the White River near Kadoka, South Dakota, the discharge of fine sediments was lower during the winter and spring than during the summer and early fall. He computed a "coefficient of seasonal adjustment" which, when plotted by month, resembles a sine wave. Therefore, sine and cosine functions were included as independent variables to be evaluated in the regression analyses for sediment-discharge calculations for Bay Creek at Nebo. The transport equations (table 3) use the base 10 logarithm of daily mean water discharges for the 1940-80 water years and day of the year to calculate monthly and yearly suspended-sediment loads for the 41 years of record.

RESULTS

The total suspended-sediment load, estimated from the transport equations for the 5 years with daily suspended-sediment records (table 4), was 77.3 percent of the total load computed from daily sediment- and water-discharge records that were used to develop the equations. A graph showing plots of the logarithms of the 5 years of computed suspended-sediment discharges versus estimated suspended-sediment discharges (fig. 8) shows a nearly one-to-one relation. An independent calculation of suspended-sediment discharge for Bay Creek at Nebo for the years 1947 through 1967 was obtained from the U.S. Army Corps of Engineers (written commun., 1980). A graph of the cumulative suspended-sediment discharge calculated by the Corps and suspended-sediment discharge estimated by the equations (fig. 9) shows that, after 1951, the Corps' data slightly exceed estimates made during this study. The disparity between the two sets of data is probably due to the change in the rainfall-runoff relation that occurred in the early 1950's (fig. 4). The equations that were used to estimate suspended-sediment discharges were based on the rainfall-runoff relation that existed after 1966. Because the relation (as indicated by the slope of the line in figure 4) was the same prior to 1951 and after 1966 and data available during the intervening years were sparse, no attempt was made to adjust the sediment discharge estimates based on this comparison.

The estimated monthly and yearly suspended-sediment loads are given in table 5. The maximum estimated yearly load was 1,384,997 tons in 1970 and the minimum was 6,752 tons in 1940. The mean annual sediment load from the estimated values was 359,500 tons, which represents a yield of about 3.5 tons per acre. The largest mean monthly suspended-sediment load for the 41 years of estimated loads was 70,100 tons for May and the smallest was 6,550 tons for December.

SUMMARY

Bay Creek is the only Mississippi River tributary in the GREAT (Great River Environmental Action Team) III study reach in Illinois for which data were available to estimate long-term suspended-sediment discharge. The U.S. Army Corps of Engineers, Rock Island District, has obtained samples for suspended-sediment concentrations at the U.S. Geological Survey gaging station near Nebo since 1966. The Erosion and Sedimentation Work Group of the GREAT III study team needed sediment-transport information for their evaluation of sediment transport to the Mississippi River by small tributary streams.

Streamflow data for Bay Creek at Nebo, Illinois, have been collected since 1940. Five years of daily suspended-sediment discharges (1968, 1969, 1975, 1976, and 1980) computed from once- or twice-weekly samples were used to develop transport equations that can be used to estimate sediment discharges from water-discharge records for the Bay Creek basin above Nebo. Because of the abrupt changes in topography from bluffs to flood plain, the sediment transport characteristics at Nebo should not be extended to the entire watershed.

The suspended-sediment load that was estimated from the equations for the 5 years with daily suspended-sediment records was 77.3 percent of that computed from daily sediment- and water-discharge records for those years. The mean annual sediment load for 41 years of estimated loads was 359,500 tons, which represents a yield of about 3.5 tons per acre from the Bay Creek drainage basin.

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Figures 1 to 9; tables 1 to 5

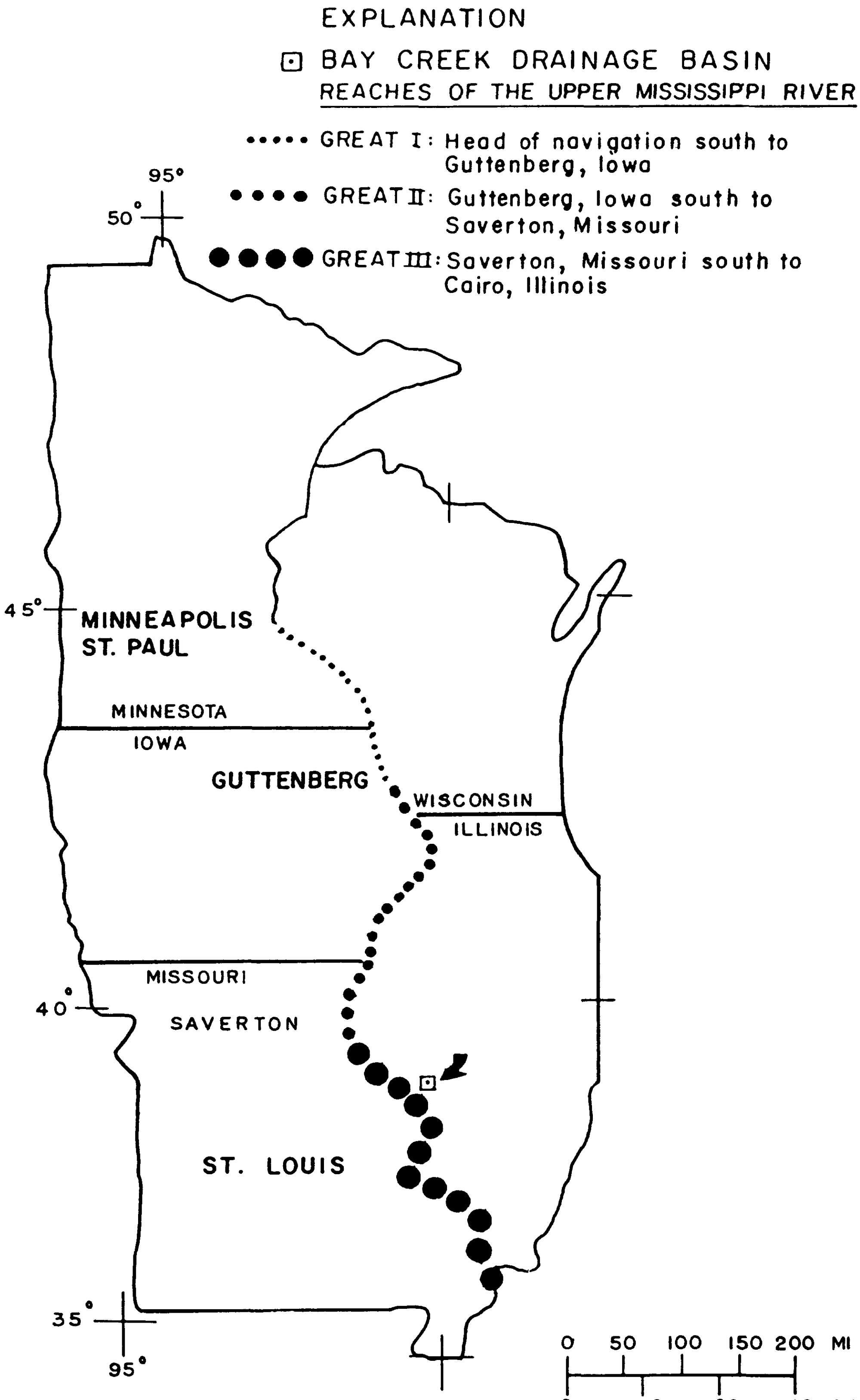


Figure 1.--Location of Bay Creek drainage basin within the GREAT III study area.

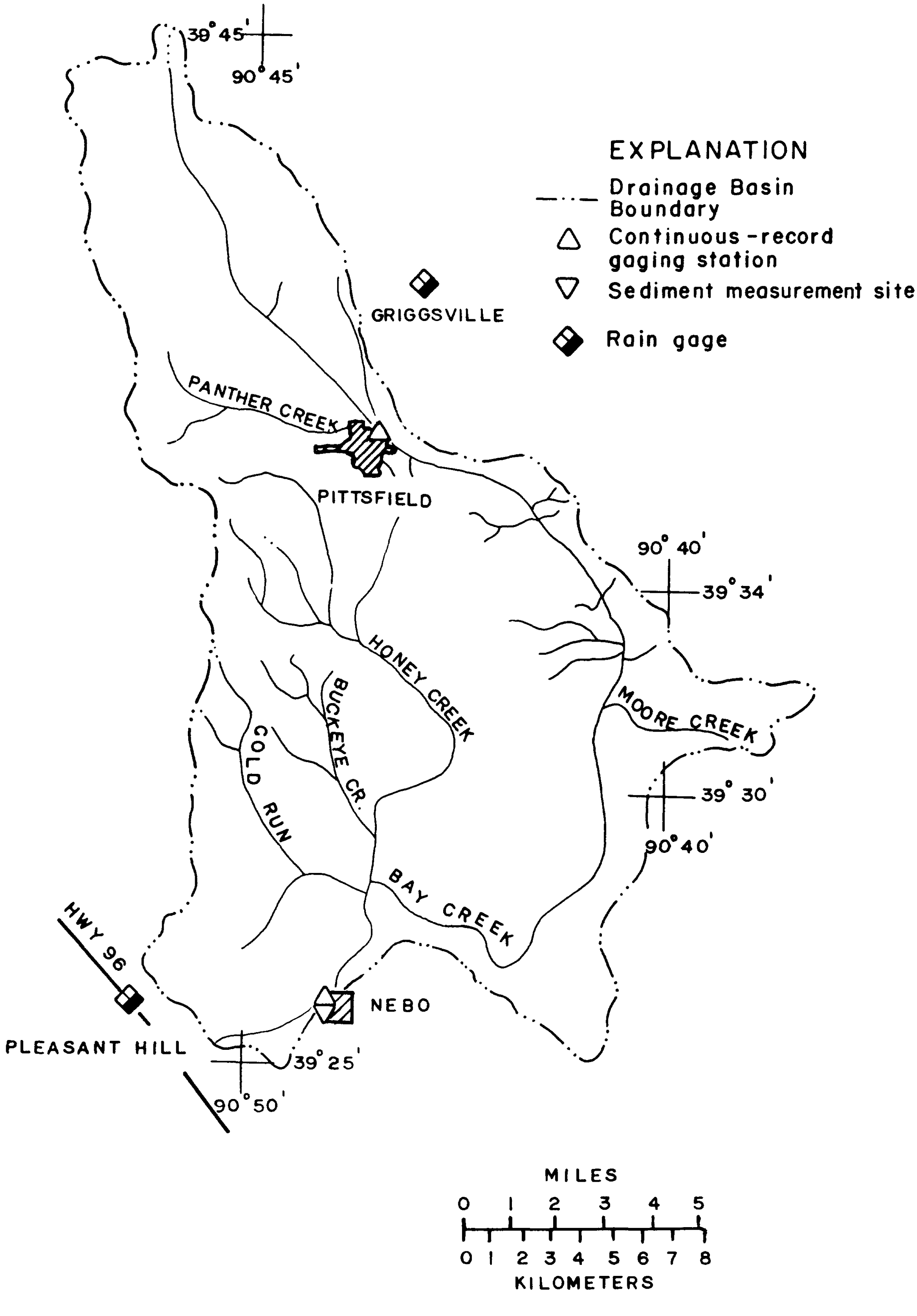


Figure 2.--Data-collection sites in the Bay Creek basin.

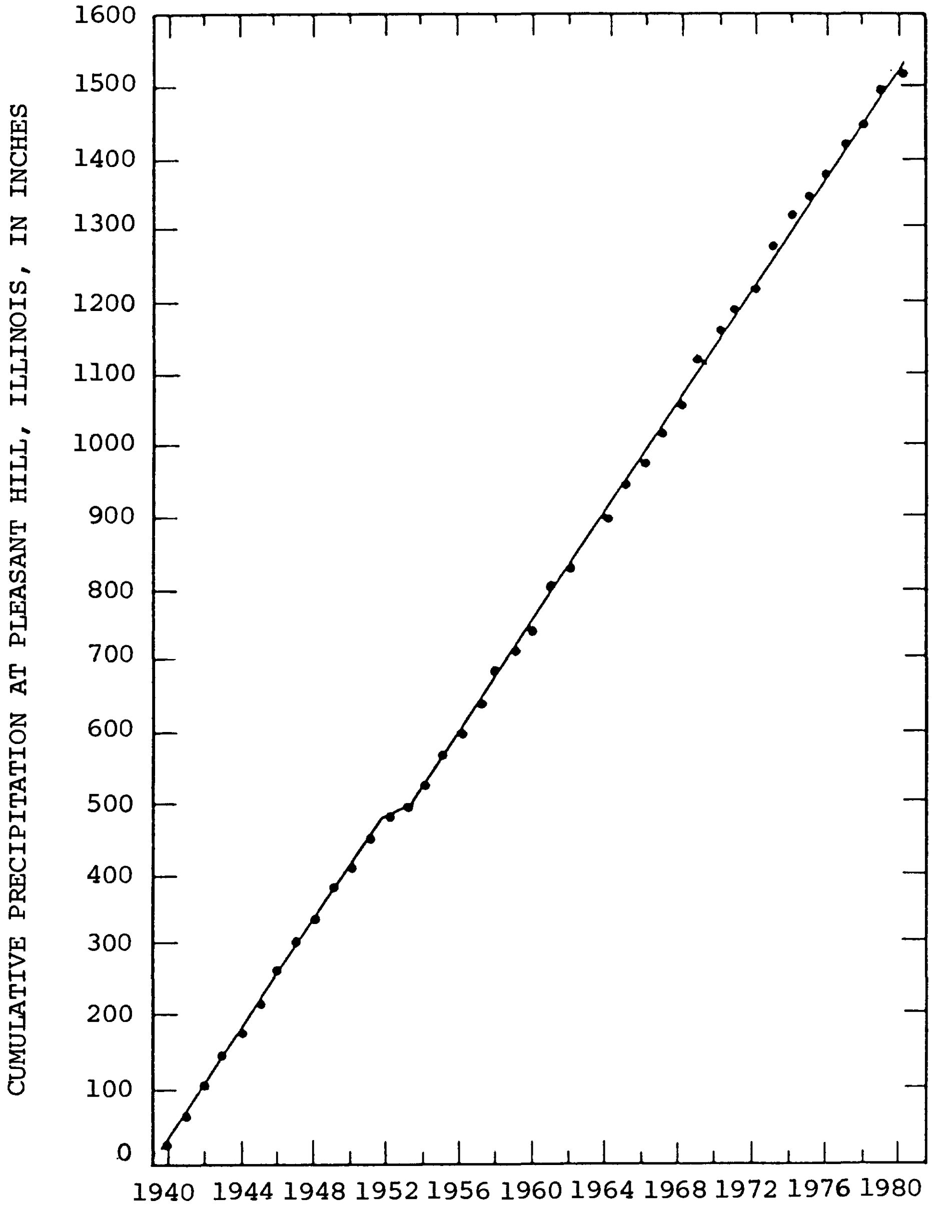


Figure 3.--Cumulative precipitation versus year.

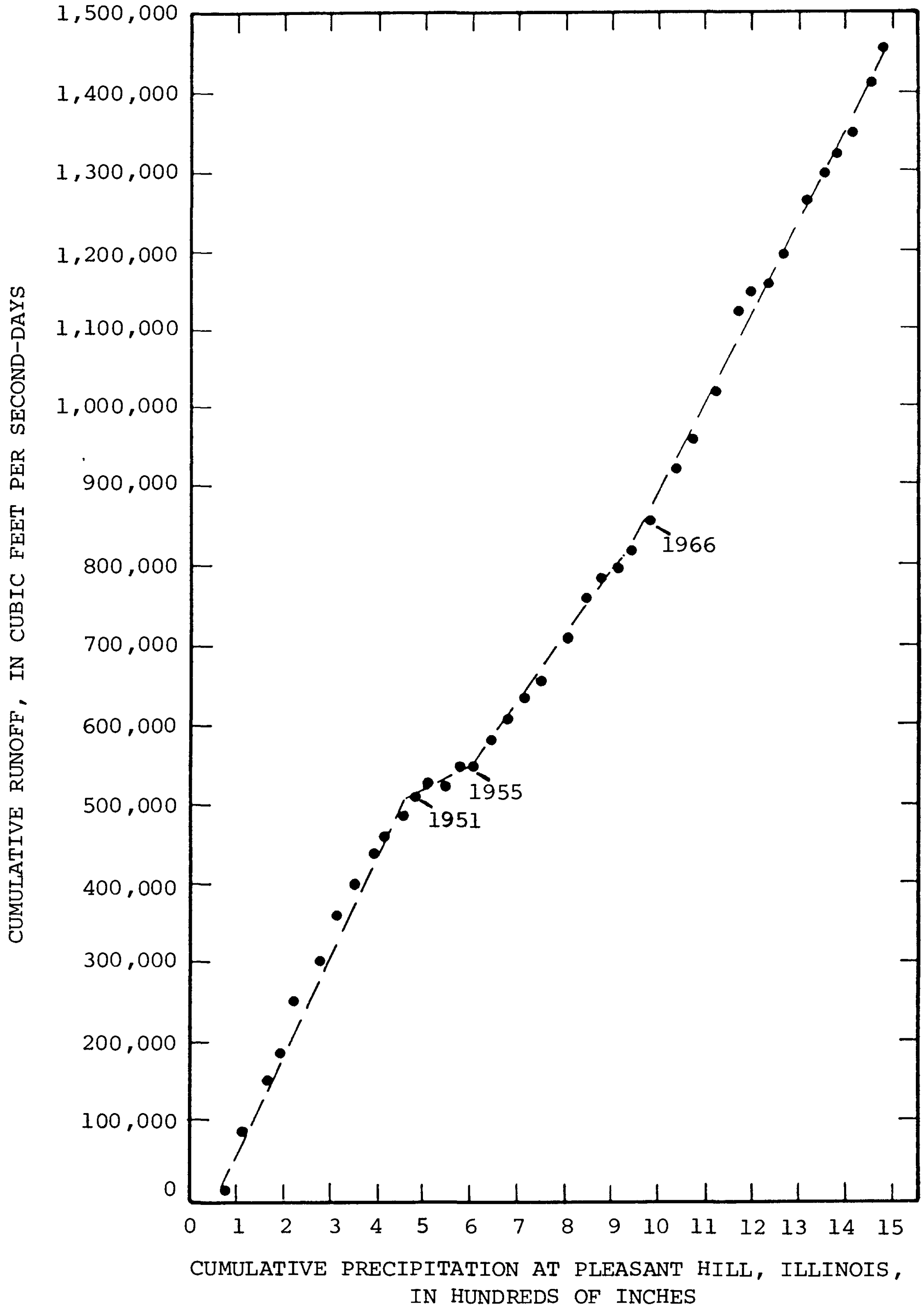


Figure 4.--Relation between rainfall and runoff in the Bay Creek drainage basin and years in which relation changed.

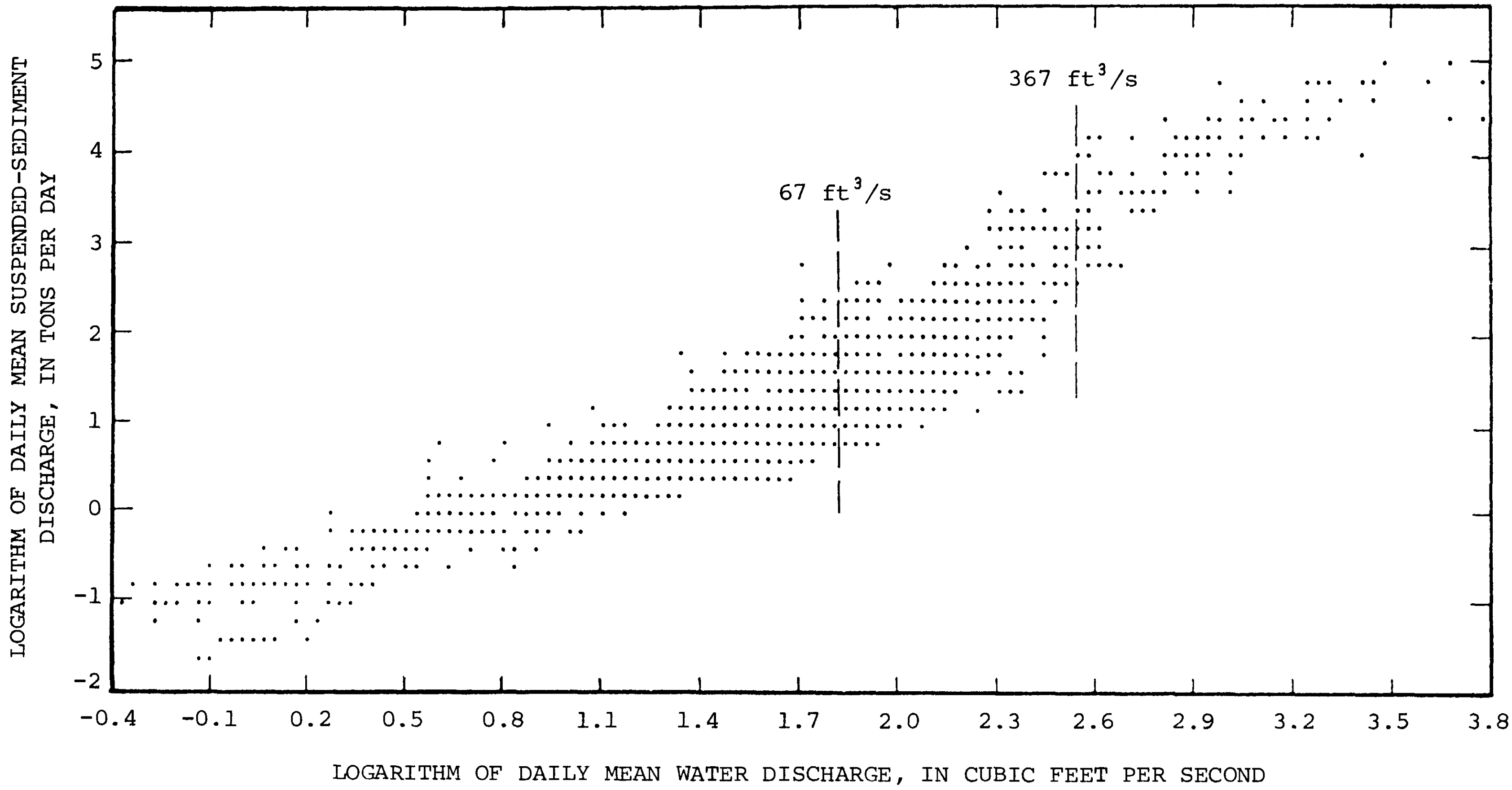
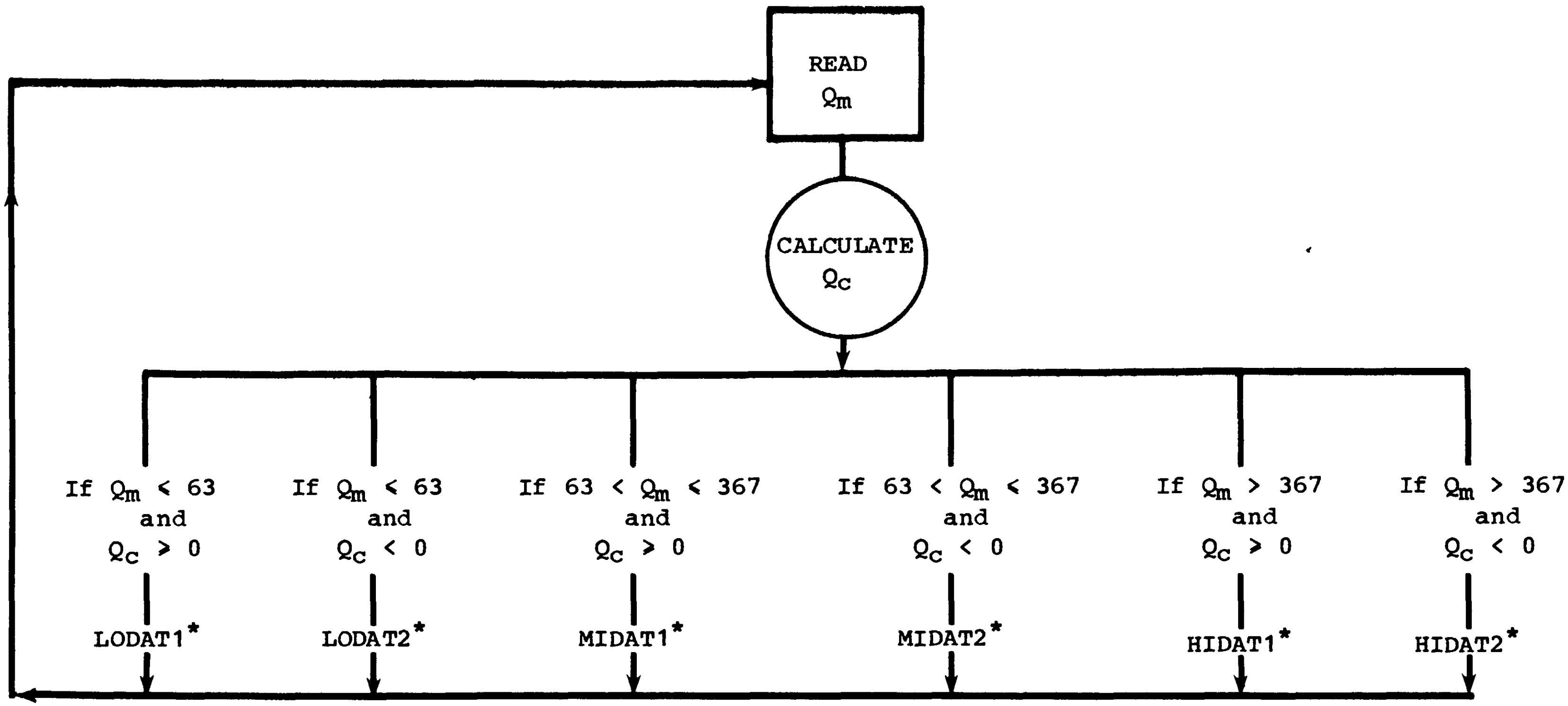


Figure 5.--Plots of logarithms of suspended-sediment discharge versus daily mean water discharge.



Q_m is daily mean water discharge, in cubic feet per second;

Q_c is change in Q_m (Q_m of any day minus Q_m of previous day);

* data set name used in computer program.

Figure 6.-- Flow chart of procedure used to partition Bay Creek data into sets for regression analyses.

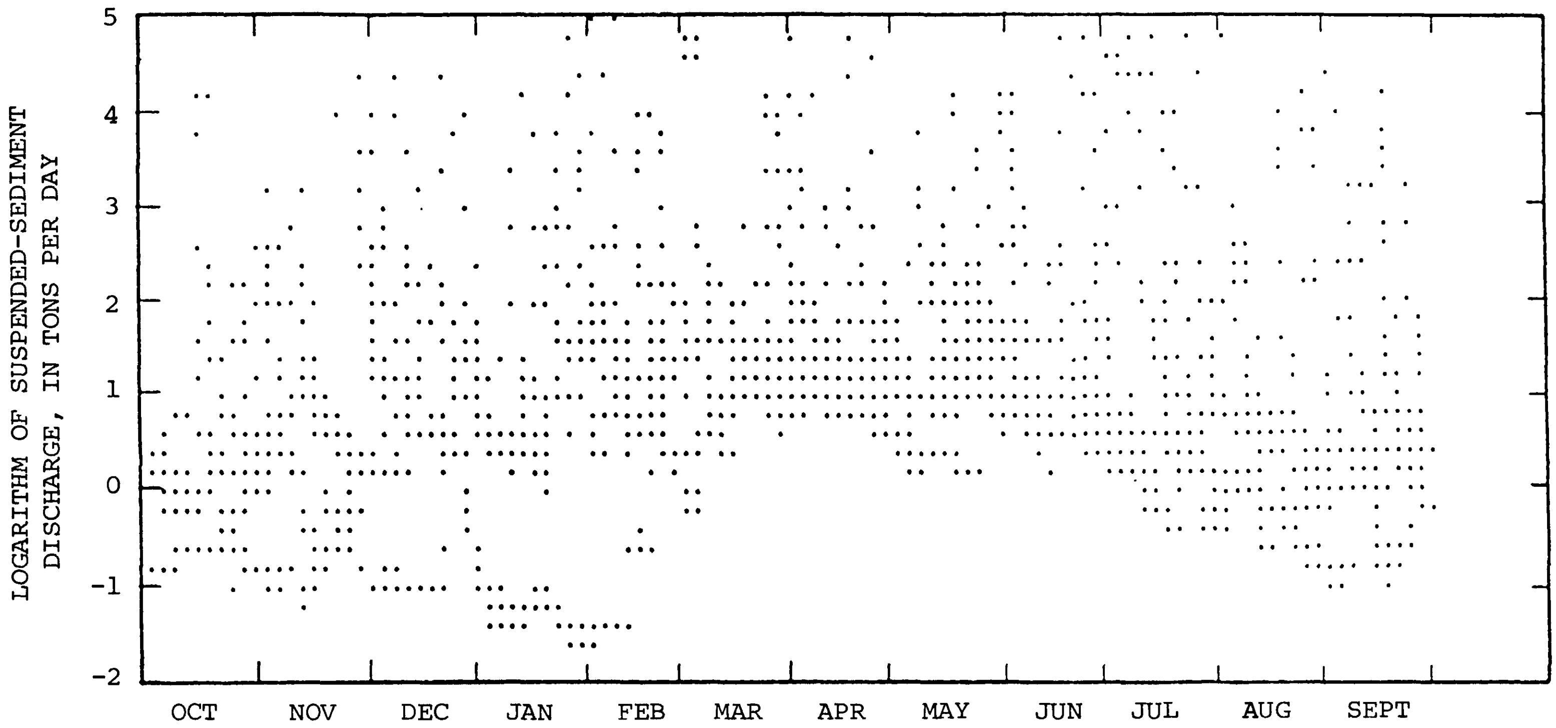


Figure 7.--Plots of logarithm of suspended-sediment discharge versus month.

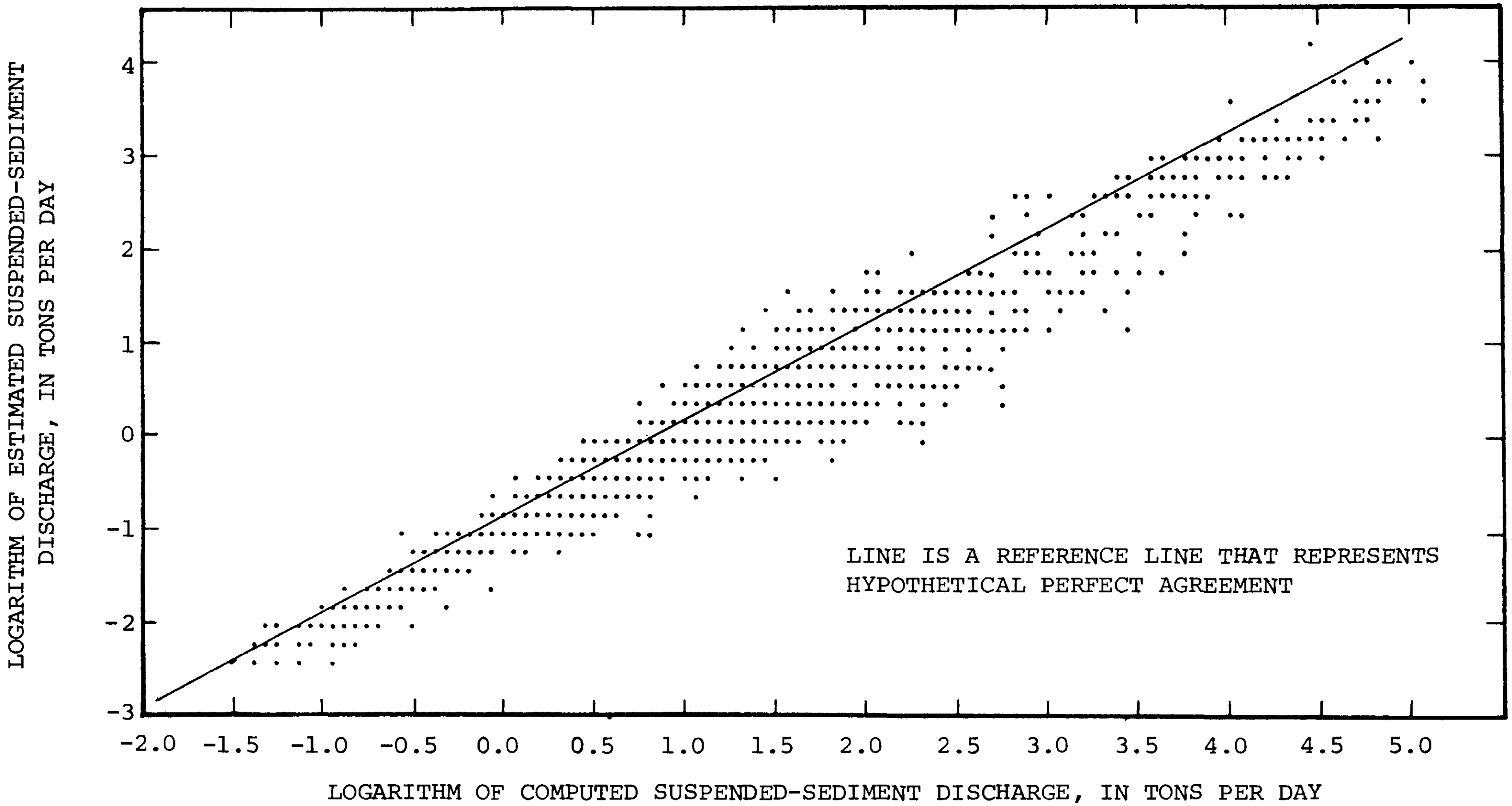


Figure 8.--Plots of logarithms of estimated suspended-sediment discharges versus 5 years of computed suspended-sediment discharges at Bay Creek at Nebo.

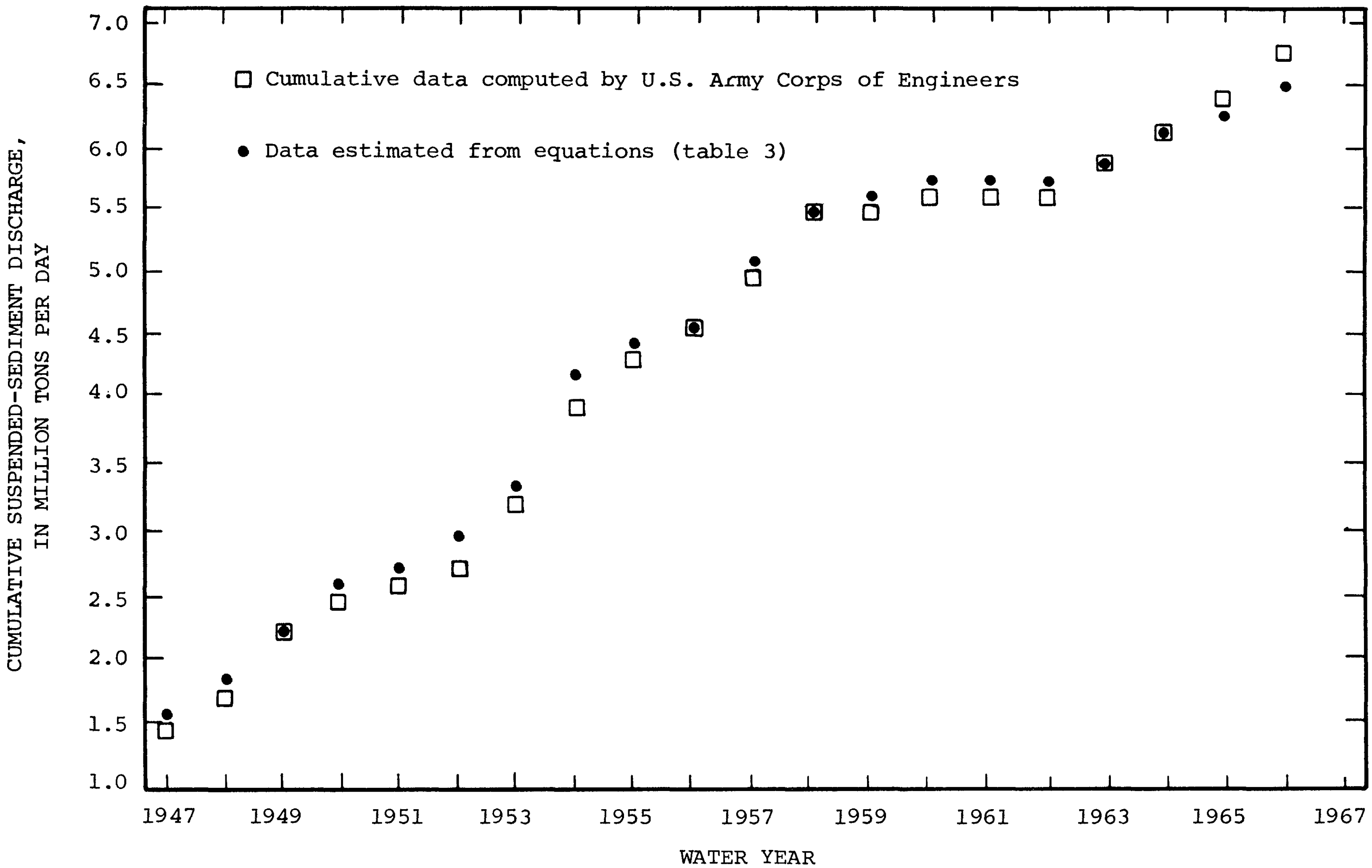


Figure 9.--Cumulative and estimated suspended-sediment discharges versus water year.

Table 1.--Particle-size distribution of bed material at Bay Creek at Nebo

Date of collection	Percentage of sample weight finer than indicated size in millimeters				
	0.5	0.25	0.125	0.062	0.004
May 28, 1980	--	--	--	99	31
July 15, 1980	92	82	79	78	21

Table 2.--Particle-size distribution of suspended sediment at Bay Creek at Nebo, 1951-80

Collection date	Instantaneous suspended-sediment concentration (milligrams per liter)	Percentage of sample weight finer than indicated size in millimeters					
		0.062	0.031	0.016	0.008	0.004	0.002
Apr. 13, 1951	-	100	77	45	29	17	-
July 28, 1951	-	92	76	54	36	21	-
Apr. 23, 1952	-	83	53	37	25	17	-
July 14, 1952	-	100	95	81	67	47	-
Apr. 12, 1955	-	85	73	57	52	42	-
Apr. 29, 1956	-	80	55	42	28	19	-
June 15, 1958	-	93	75	51	35	13	-
Apr. 16, 1960	-	97	82	67	53	37	-
Aug. 26, 1965	-	63	45	27	18	10	-
June 16, 1966	-	93	48	30	21	14	-
Feb. 1, 1968	8,800	97	79	40	24	20	17
Oct. 14, 1968	10,200	97	79	47	46	27	20
Jan. 23, 1969	9,160	95	76	44	28	22	17
Feb. 8, 1969	13,000	97	80	49	29	24	20
Mar. 24, 1969	42,300	93	68	32	19	16	14
Apr. 5, 1969	9,530	95	76	36	21	17	14
May 31, 1969	27,800	99	93	58	37	30	28
June 1, 1970	12,900	97	88	57	41	34	26
Apr. 16, 1972	14,500	99	68	55	42	33	27
Mar. 6, 1973	31,600	98	85	52	33	24	22
Apr. 22, 1973	6,300	99	94	75	61	52	44
Oct. 13, 1973	7,670	99	-	59	39	27	24
Dec. 4, 1973	5,740	97	-	50	33	26	22
Jan. 27, 1974	5,390	95	-	53	41	33	33
May 3, 1974	20,500	97	-	50	34	26	22
July 10, 1974	10,600	-	-	78	55	42	34
July 28, 1974	4,550	-	-	94	75	60	49
Jan. 10, 1975	9,070	99	-	61	52	41	32
Mar. 28, 1975	9,350	98	-	58	41	33	28
Apr. 24, 1975	20,100	97	-	-	37	30	24
May 8, 1975	19,800	98	-	52	36	29	24
May 30, 1975	20,300	100	-	73	52	39	31
June 5, 1975	57,400	99	-	52	33	24	20
June 18, 1975	5,650	100	-	95	81	67	59
June 27, 1975	13,600	99	-	63	47	35	27

Table 2.--Particle-size distribution of suspended sediment at Bay Creek at Nebo, 1951-80--Continued

Collection date	Instantaneous suspended-sediment concentration (milligrams per liter)	Percentage of sample weight finer than indicated size in millimeters					
		0.062	0.031	0.016	0.008	0.004	0.002
Feb. 16, 1976	10,100	97	-	50	33	26	22
Feb. 21, 1976	11,500	98	-	47	34	27	24
Mar. 4, 1976	3,140	-	-	78	74	56	48
May 22, 1976	-	100	-	79	61	58	37
Sept. 9, 1976	2,080	99	-	97	88	70	61
Feb. 24, 1977	2,450	-	-	82	67	57	48
May 5, 1977	13,000	99	-	68	48	39	34
Mar. 12, 1977	8,310	99	-	65	49	41	34
Aug. 6, 1977	11,900	99	-	62	41	30	26
Oct. 1, 1977	7,990	98	-	57	52	32	26
Apr. 11, 1978	3,820	-	-	63	44	38	31
May 7, 1978	5,920	-	-	47	-	33	27
May 13, 1978	7,610	-	-	55	-	31	25
June 18, 1978	4,670	100	-	85	73	63	54
Apr. 11, 1979	9,960	99	-	49	38	33	33
Apr. 11, 1979	7,750	99	-	64	43	43	39
June 8, 1979	17,800	100	-	76	51	39	35
June 9, 1979	3,260	100	-	97	84	79	58
Mar. 30, 1980	5,040	100	-	72	56	48	43
*Apr. 22, 1980	123	98	-	-	-	-	-
May 17, 1980	22,600	99	-	66	49	40	32
May 18, 1980	8,930	100	-	90	73	57	55
*May 27, 1980	196	100	-	-	-	-	-
June 4, 1980	2,480	100	-	97	92	81	70
*July 9, 1980	82	99	-	-	-	-	-
*July 22, 1980	5,250	100	-	93	71	61	48
*Aug. 6, 1980	2,270	100	-	96	89	76	65
*Aug. 20, 1980	337	100	-	97	-	84	72
Sept. 2, 1980	7,670	100	-	59	41	37	33
*Oct. 8, 1980	24	98	-	-	-	-	-
*Nov. 5, 1980	41	99	-	-	-	-	-

* Sample collected as part of this study. All other analyses furnished by U.S. Army Corps of Engineers, Rock Island District.

Table 3.--Equations for estimating suspended-sediment discharges from long-term streamflow records at Bay Creek at Nebo

[Q_m is daily mean water discharge, in cubic feet per second; Q_s is daily sediment discharge in tons per day; $T = b \times d$; b is a constant used to convert the day of the year to an angle in radians (1 day = $2\pi \div 365.25$ radians); d is the day of the year; for October 1, d = 1; for September 30, d = 365 or 366]

Range of daily mean discharge (in cubic feet per second)	Equation	Number of data points	Standard error of estimate
1. 0-63 steady or increasing discharge	$\log Q_s = -1.07 + 1.285 \log Q_m - 0.255 \sin(T) + 0.153 \cos(T)$	370	+74 -43
2. 0-63 decreasing discharge	$\log Q_s = -1.04 + 1.268 \log Q_m - 0.224 \sin(T) + 0.119 \cos(T)$	837	+75 -43
3. >63-367 steady or increasing discharge	$\log Q_s = -3.17 + 2.544 \log Q_m - 0.351 \sin(T) + 0.264 \cos(T)$	176	+152 -60
4. >63-367 decreasing discharge	$\log Q_s = -2.97 + 2.353 \log Q_m - 0.295 \sin(T) + 0.197 \cos(T)$	353	+131 -57
5. >367 steady or increasing discharge	$\log Q_s = 0.34 + 1.261 \log Q_m - 0.169 \sin(T) + 0.021 \cos(T)$	74	+106 -51
6. >367 decreasing discharge	$\log Q_s = -0.96 + 1.646 \log Q_m - 0.118 \sin(T) - 0.086 \cos(T)$	30	+84 -46

Table 4.--Computed and estimated suspended-sediment loads

Water year	Total from sediment records	Total from estimating equations	Ratio of estimated to measured load, in percent
1968	432,201	279,563	64.7
1969	579,057	492,424	85.0
1975	205,046	191,707	93.5
1976	142,407	70,039	49.2
1980	160,737	141,272	87.9
Total	1,519,448	1,175,005	77.3

Table 5.--Estimated monthly and annual suspended-sediment loads, in tons, at Bay Creek at Nebo, 1940-80

Water	Monthly suspended-sediment loads												Annual
year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	total
1940	8	8	0	0	42	579	49	65	291	0	5,709	1	6,752
1941	9	20	1	99	24	10	33,036	144	10,124	11,198	0	18,114	72,779
1942	312,883	44,659	519	98	76,121	93,223	31,244	121,604	160,154	92,041	359	14,054	946,959
1943	115	61,996	93,085	796	6,993	919	204	573,495	62,199	8,372	6,237	662	815,073
1944	9	4,537	32	206	4,437	15,993	277,223	47,544	123	17	11	5	350,137
1945	802	22	0	121	567	61,647	90,775	35,345	637,667	36,400	19,936	85,327	968,609
1946	11,228	511	4,115	38,525	4,780	1,641	239	79,231	36,713	10,874	575,318	6,291	769,466
1947	23,239	222,192	3,254	1,776	138	19,966	235,735	32,255	108,550	54,822	34	4	701,965
1948	2	37	205	87	9,186	74,552	1,025	14,523	20,459	165,098	1,005	34	286,213
1949	16	49	59	26,151	23,963	35,235	1,172	10,196	41,568	95,747	257	2,137	236,550
1950	18,994	71	35,498	14,801	10,644	16,929	25,554	544	151	86	505	13	123,790
1951	2	14	1	844	73,176	15,716	11,985	10,615	17,120	16,892	4,963	3,783	155,111
1952	5,157	6,115	5,074	4,292	4,685	20,067	41,265	8,062	30,520	617	117	23	125,994
1953	0	386	15	12	6	4,790	1,555	2,705	17	325	16	0	9,827
1954	0	0	0	0	0	394	4,820	21	18	31,069	13,958	2,503	52,783
1955	5,013	33	13	7,131	24,476	168	11,616	30,521	2,373	943	38,362	12	120,661
1956	27,926	8	0	0	9	0	18,912	5,492	26,329	374	2,999	1	82,050
1957	0	0	35	110	92	11,965	76,971	186,557	179,097	987	601	0	456,415
1958	9,970	19	788	34	744	114	6,185	17,890	49,822	346,776	36,671	5,803	474,816
1959	970	19,131	47	3,851	63,184	5,717	7,622	3,132	66	8	27	275	104,030
1960	14,044	17	30	33	210	103,072	91,038	43,614	34,866	10,752	55	9	297,740
1961	0	19	0	11	4,002	1,025	10,629	183,804	11,981	35,269	389,306	215,403	851,449
1962	484	13,229	347	13,410	7,520	101,126	617	22,745	106,773	135,642	5,877	1,790	409,560
1963	812	40	30	13	107	49,437	144	88,821	1,772	51,715	27,616	5,843	226,350
1964	0	17	0	248	39	1,296	38,989	764	602	86	1,120	23	43,184
1965	0	8,949	16	630	84	1,754	28,811	198	73,660	14,897	89,365	208,957	427,321
1966	154	48	287	47	19,148	248	36,200	276,238	29,995	74	178	11,776	374,393
1967	1,061	482	4,141	163	452	12,102	2,308	26,450	29,658	160,590	2,430	8,157	247,994
1968	19,639	2,299	52,288	8,443	15,154	301	1,297	7,358	7,192	115,549	47,072	2,971	279,563
1969	20,778	17,773	10,384	67,281	27,636	27,560	59,401	15,687	63,520	169,268	5,537	7,599	492,424
1970	246,471	515	113	7,438	175	5,842	126,831	347,138	391,802	18,858	76,231	163,583	1,384,997
1971	63,588	3,153	2,058	8,930	23,356	633	198	1,680	440	273	25	225	104,559
1972	745	20	6,610	87	165	8,994	28,446	706	87	38	183	29	46,110
1973	21	394	8,410	1,594	354	101,432	165,181	11,977	16,565	11,031	1,768	3,890	322,617
1974	23,780	2,573	24,772	70,754	26,644	6,281	43,080	176,757	55,679	1,084	2,906	352	434,662
1975	56	2,255	1,590	14,621	20,666	26,323	42,491	16,787	26,005	147	21,895	18,871	191,707
1976	132	8,096	1,414	341	13,609	42,240	474	2,546	197	86	544	360	70,039
1977	330	5	0	0	12,188	28,269	730	200,527	59	2,062	16,939	6,437	267,546
1978	48,726	36,796	9,049	126	29	191,180	72,589	103,173	7,272	85,641	4,366	53,123	612,070
1979	21	242	4,201	52	57,362	68,976	347,974	160,018	9,421	1,370	3,218	6	652,861
1980	0	3	149	0	342	18,719	21,435	8,651	16,756	1,184	28,029	46,004	141,272
Mean	20,900	11,100	6,550	7,150	13,000	28,700	48,700	70,100	55,300	41,200	34,900	21,800	359,500

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