PRELIMINARY EVALUATION OF MAGNITUDE AND FREQUENCY OF FLOODS IN SELECTED SMALL DRAINAGE BASINS IN OHIO

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CONVERSION FACTORS

For the convenience of readers who prefer to use metric (International System) units, conversion factors for the inch-pound terms used in this report are listed below:

Multiply inch-pound units	By	To obtain metric units
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
inch (in.)	25.40	millimeter (mm)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$°C = 0.556\ (°F - 32)$$

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ABSTRACT

A previous study of flood magnitudes and frequencies in Ohio concluded that existing regionalized flood equations may not be adequate for estimating peak flows in small basins that are heavily forested, surface mined, or located in northwestern Ohio.

In order to provide a large data base for improving estimation of flood peaks in these basins, 30 crest-stage gages were installed in 1977, in cooperation with the Ohio Department of Transportation, to provide a 10-year record of flood data.

The study area consists of two distinct parts: Northwestern Ohio, which contains 8 sites, and southern and eastern Ohio, which contains 22 sites in small forested or surface-mined drainage basins. Basin characteristics were determined for all 30 sites for 1978 conditions.

Annual peaks were recorded or estimated for all 30 sites for water years 1978-82; an additional year of peak discharges was available at four sites. The 2-year (Q_2) and 5-year (Q_5) flood peaks were determined from these annual peaks. Q_2 and Q_5 values also were calculated using published regionalized regression equations for Ohio. The ratios of the observed to predicted 2-year (R_2) and 5-year (R_5) values were then calculated.

This study found that observed flood peaks are lower than estimated peaks by a significant amount in surface-mined basins. The average ratios of observed to predicted R_2 values are 0.51 for basins with more than 40 percent surface-mined land, and 0.68 for sites with any surface-mined land. The average R_5 value is 0.55 for sites with more than 40 percent surface-mined land, and 0.61 for sites with any surface-mined land.

Estimated flood peaks from forested basins agree with the observed values fairly well. R_2 values average 0.87 for sites with 20 percent or more forested land, but no surface-mined land, and R_5 values average 0.96. If all sites with more than 20 percent forested land and some surface-mined land are considered, the R_2 values average 0.86, and the R_5 values average 0.82.

Estimated flood peaks from the published equations are lower than the observed flood peaks in the northwestern Ohio sites. The R_2 values average 1.89, and the R_5 values average 2.56. Observed peaks for both the 2-year and the 5-year floods are higher at all eight sites.

Some preliminary regression analyses indicate that revised equations for estimating flood magnitude and frequency can be developed after a longer period of data collection than the 5-year period used in this study.

INTRODUCTION

Background

Flood magnitude and frequency data for streams are used in the design of dams, bridges, levees, and other structures. Flood data are also used in flood-insurance studies, land zoning, and regulatory activities. Flood data from small basins are helpful in the design of culverts and small flood-control structures and for studies to determine the effect of land use on flood peaks.

Four Ohio flood-frequency reports have been prepared by the U.S. Geological Survey. Three of these (Cross, 1946; Cross and Webber, 1959; and Cross and Mayo, 1969) were prepared in cooperation with the Ohio Department of Natural Resources, Division of Water. The fourth (Webber and Bartlett, 1977) was prepared in cooperation with the Ohio Department of Transportation and the Federal Highway Administration, and was published by the Ohio Department of Natural Resources, Division of Water, as their Bulletin 45; it is referred to hereafter in this report simply as "Bulletin 45".

Webber and Bartlett (1977) determined that further investigations of flood magnitude and frequency were needed in four specific areas. These areas include the northwestern corner of Ohio and urban, forested, and surface-mined areas. This study is designed to provide data for all but the urban basins.

An investigation in cooperation with the Ohio Department of Transportation that began in 1978 is intended to provide a 10-year record of flood data from 30 small basins located in forested and (or) surface-mined areas and in the northwestern corner of Ohio. Reconnaissance and installation of 30 crest-stage gages was completed by October 1977. Data collection began in the 1978 water year and will continue through the 1987 water year.

Purpose and Scope

The purpose of this report is (1) to present the data that have been collected in the first 5 years of the study (1978-82), (2) to compare observed flood peaks to those estimated from published equations, and (3) to determine the feasibility of developing new equations to estimate magnitude and frequency of flood peaks at ungaged sites on unregulated streams in northwestern Ohio and in forested and surface-mined areas.

This is a preliminary report. The data presented are incomplete and all interpretations are preliminary. Final conclusions will not be possible until the project is completed.

Description of Area and Sites Studied

The study area is in two distinct parts. Eight basins are located in the western end of the Maumee River basin in northwestern Ohio (fig. 1). Another 22 basins are located in southern and eastern Ohio in forested and (or) surface-mined areas. Nine basins are more than 20 percent forested and have no surface mining. Thirteen basins have some surface-mined land, seven of which are more than 40 percent surface mined. One basin is less than 20 percent forested and also less than 40 percent surface mined. Five basins are more than 20 percent forested but also contain some surface-mined land. For this preliminary report, the 20-percent forested value was chosen to group those basins in which forest is the primary land use. The 40-percent value for surface-mined land was chosen to attempt to isolate those basins in which the primary land use is surface mining. The category of each station is shown in figure 1.

The topography of the two parts is very different. The northwestern sites are located in a flat, glaciated, old-lake-bed region. The southern and eastern sites are located in an unglaciated, hilly region.

The climate of both parts is humid continental and temperate. Annual precipitation ranges from 32 to 44 inches. The northwestern part tends to have lower average annual precipitation, generally in the range of 32 to 36 inches, whereas the southern and eastern part generally has average annual precipitation in the 39- to 43-inch range (Ohio Department of Natural Resources, Division of Water, 1982).

BASIN CHARACTERISTICS

Basin characteristics for all sites were computed for 1978 conditions. Aerial photographs also were obtained to document 1978 surface-mining and forest conditions.

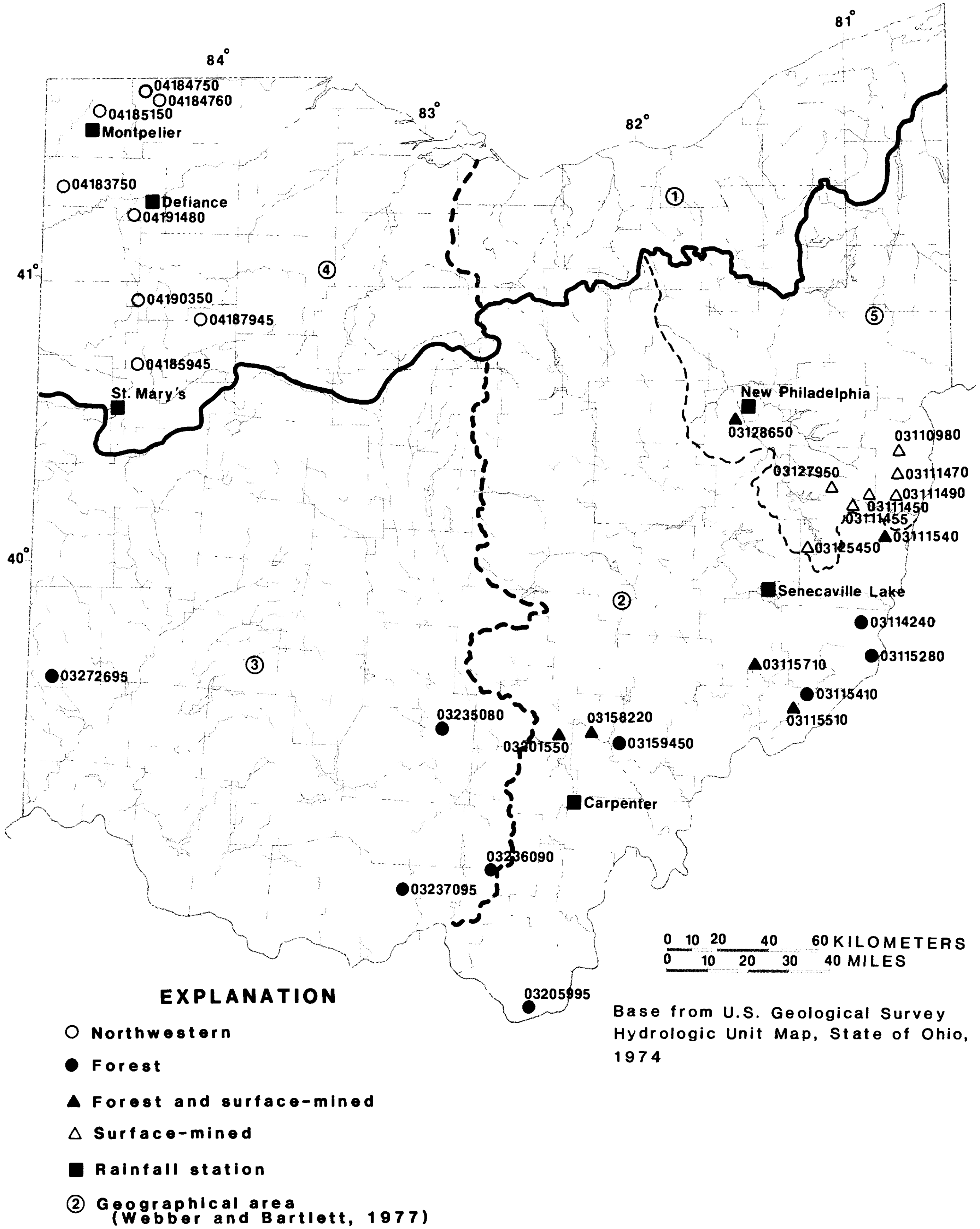

Figure 1.--Location of sites studied and rainfall stations.

The 30 study sites are located in small basins ranging from 0.04 to 10.9 square miles; 26 of the basins range from 0.3 to 2.0 square miles. The ranges of drainage areas are about the same for the northwestern part and the southern and eastern part.

Other basin characteristics computed are main-channel slope, stream length, mean basin elevation, average of channel elevations (computed by averaging the elevations at the 10- and 85-percent distance points along the channel), percent surface storage, percent forested area, percent surface-mined area, mean annual precipitation, precipitation intensity (24-hour rainfall expected on the average of every 2 years), and mean minimum January temperature (Dempster, 1982). These characteristics are listed in table 1. All basin characteristics except climatic values were determined from U.S. Geological Survey topographic maps.

The main-channel slopes of the drainage basins are considerably different between the northwestern sites (where the slope ranges between 8.4 and 30.8 feet per mile) and the southern and eastern sites (where the slope ranges from 37.9 to 500 feet per mile). This is due to the flatter topography in northwestern Ohio.

Stream lengths range from 0.27 to 5.98 miles; ranges are similar for both the northwestern and southern and eastern sites. Mean basin elevation ranges from 1,250 to 735 feet above sea level in the southern and eastern sites and from 850 to 710 feet above sea level in the northwest. Similarly, the average of channel elevations ranges from 1,240 to 650 feet above sea level in the south and east and from 835 to 700 feet in the northwest.

The percentage of surface storage ranges from 0 to 2.5 percent. Values are similar for both the northwestern and the southern and eastern sites.

The percentage of forested area ranges from 1.5 to 84.9 percent in the southern and eastern sites, but ranges only from 2.4 to 11 percent in the northwest. The northwestern sites are in agricultural areas, thus, they have less forested land. Fourteen basins are more than 20 percent forested.

The percentage of surface-mined area ranges from 0 to 81.7 percent. The northwestern sites have no surface mining. Thirteen sites in the southern and eastern part have some surface mining in the basin. The sites with some mining range from 2.3 to 81.7 percent mined.

The precipitation intensity ($I_{24,2}$) ranges from 2.4 to 2.9 inches and is similar for both parts of the study area (U.S. Department of Commerce, 1961). The mean minimum January temperatures range from 20.5 to 28.0°F at the southern and eastern sites and from 19.0 to 21.0°F at the northwestern sites (Pierce, 1959).

Table 1.--Basin characteristics for sites studied

Station number	Station name	Latitude of gage	Longitude of gage	Drainage area (mi^2)	Main channel slope (ft/mi)	Stream length (mi)	Mean basin elevation (ft)	Elevation 10-85[a] (ft)	Surface storage (%)	Forested area (%)	Surface mined area (%)	Mean annual precipitation (in.)	Precipitation intensity[b] (in.)	January mean minimum temperature (deg. F)
03110980	Consol Run at Bloomingdale	40.332	80.812	0.04	500	0.27	1,250	1,240	0.0	11.0	67.0	39.0	2.5	22.0
03111450	Branson Run at Georgetown	40.207	80.923	1.31	95.2	2.24	1,110	1,060	.8	3.1	81.7	39.5	2.5	21.0
03111455	S. Fk. Short Cr. at Georgetown	40.208	80.920	10.9	37.9	5.98	1,150	1,040	2.5	1.5	78.0	39.5	2.5	21.5
03111470	Lt. Piney Fork at Parlett	40.302	80.849	1.57	78.8	2.20	1,220	1,140	1.9	12.7	51.0	39.0	2.5	22.5
03111490	Piney Fk. Trib. nr Piney Fk.	40.272	80.847	.44	130	1.63	1,130	1,080	.9	19.3	48.3	39.0	2.5	22.5
03111540	Sloan Run Trib. nr Harrisville	40.152	80.883	.34	254	.87	1,160	1,100	.0	13.2	14.7	39.5	2.5	22.0
03114240	Wood Run nr Woodsfield	39.782	81.056	.53	246	1.63	1,120	1,010	.0	36.8	.0	41.5	2.5	24.0
03115280	Trail Run nr Antioch	39.625	81.048	5.45	90.3	3.03	985	820	.0	61.1	.0	42.0	2.5	25.0
03115410	Graham Run nr Bloomfield	39.543	81.209	.13	289	.61	805	755	.0	52.6	.0	41.5	2.5	25.0
03115510	Moss Run nr Wingett	39.473	81.314	1.52	114	1.97	865	775	.0	53.3	2.3	40.5	2.5	26.0
03115710	Buffalo Run Trib. nr Dexter City	39.661	81.449	.19	366	.95	960	890	.0	47.9	39.5	40.0	2.5	23.5
03125450	Robinson Run nr Hendrysburg	40.086	81.174	1.97	95.6	2.73	1,130	1,040	.5	7.6	61.5	40.5	2.5	21.5
03127950	Clear Fork nr Jewett	40.324	81.022	5.45	57.4	3.98	1,150	1,050	1.1	20.9	41.7	40.0	2.5	20.5
03128650	Mud Run Trib. at Wainwright	40.419	81.416	.55	101	1.14	995	915	1.8	55.5	25.5	39.5	2.4	22.5
03158220	Glen Run nr Doanville	39.402	82.196	1.09	94.4	1.69	820	760	.9	44.0	20.2	39.5	2.5	24.0

Table 1.--Basin characteristics for sites studied--Continued

Station number	Station name	Latitude of gage	Longitude of gage	Drainage area (mi^2)	Main channel slope (ft/mi)	Stream length (mi)	Mean basin elevation (ft)	Elevation 10-85[a] (ft)	Surface storage (%)	Forested area (%)	Surface mined area (%)	Mean annual precipitation (in.)	Precipitation intensity[b] (in.)	January mean minimum temperature (deg. F)
03159450	Mill Creek nr Chauncey	39.379	82.084	1.48	80.4	2.23	830	750	0.7	59.5	0.0	39.5	2.5	24.5
03201550	Starr Run nr New Plymouth	39.396	82.347	.30	176	.72	905	830	.7	73.3	5.0	39.5	2.5	23.0
03205995	Sandusky Creek nr Burlington	38.418	82.510	.73	124	1.52	740	630	.0	84.9	.0	42.5	2.7	28.0
03235080	Bull Creek nr Adelphi	39.453	82.779	3.13	60.4	3.60	990	905	.0	70.0	.0	39.5	2.5	24.5
03236090	S. Br. Lt. Salt Cr nr Jackson	39.014	82.650	1.28	69.8	1.86	815	765	.4	47.7	.0	41.5	2.6	25.5
03237095	Devers Run at Lucasville	38.882	83.020	1.22	131	2.08	735	650	.4	73.8	.0	41.5	2.7	27.0
03272695	Trippetts Br. at Camden	39.634	84.652	.33	144	1.29	965	950	.6	37.9	.0	39.0	2.9	24.0
04183750	Racetrack Run at Hicksville	41.316	84.767	.34	30.8	1.25	810	805	.0	7.4	.0	34.0	2.6	19.5
04184750	Spring Creek at Fayette	41.676	84.330	2.58	21.5	3.22	820	805	.0	3.1	.0	33.5	2.6	19.0
04184760	Bean Creek Trib. nr Fayette	41.652	84.293	.56	28.7	1.44	755	745	.9	6.2	.0	33.5	2.6	19.0
04185150	Beaver Creek Trib. nr Montpelier	41.572	84.518	.40	45.0	1.06	845	840	1.2	2.5	.0	34.0	2.6	19.0
04185945	Auglaize R. Trib. nr Spencerville	40.708	84.318	.51	25.9	1.86	850	845	.0	3.9	.0	36.0	2.7	21.0
04187945	Rattlesnake Cr. nr Cairo	40.822	84.071	1.45	11.0	1.70	840	830	.0	11.0	.0	36.0	2.7	20.5
04190350	Lt. Auglaize R. Trib. at Ottoville	40.918	84.346	1.04	8.5	2.99	755	750	.0	2.4	.0	36.0	2.7	20.5
04191480	Beetree Run nr Junction	41.222	84.409	1.66	8.4	2.23	710	700	.2	10.5	.0	33.0	2.6	19.5

[a]Average of channel elevations at the 10- and 85-percent distance points along the channel.
[b]Amount of rainfall in a 24-hour period expected to be equaled or exceeded an average of every 2 years.

OBSERVED ANNUAL FLOOD PEAKS

Annual peaks have been recorded or estimated for all 30 stations for the water years 1978-82 at each station. An additional year of peak discharges is available for four stations. These annual peak discharges are presented in table 2. Gage heights of peak flow have been measured on crest-stage indicators and applied to rating curves to determine discharges. Theoretical culvert ratings were used at 27 of the sites, some of which were checked by current-meter and (or) indirect discharge measurements. Three of these sites are at bridges where theoretical ratings were not practical; the ratings at these sites were developed from current-meter and indirect discharge measurements.

COMPARISON OF OBSERVED FLOOD PEAKS WITH FLOOD PEAKS PREDICTED BY PUBLISHED REGRESSION EQUATIONS

Method of Regression Analysis

Preliminary data analyses were made to compare observed flood peaks to peaks determined from equations published in Bulletin 45 (Webber and Bartlett, 1977). A preliminary regression analysis also was done. The five or six flood peaks available at each site were plotted on standard log-probability paper. Recurrence intervals were calculated from the formula:

$$T = (n + 1)/m$$

where T = recurrence interval, in years;
n = number of years of record;
m = order number of the peaks; and beginning with the largest peak as number 1.

A straight line visually fit to the data was drawn and the 2-year and 5-year flood peaks were determined from this line. Estimated peaks were determined from basin characteristics and the equations for the appropriate geographical areas found in Bulletin 45 (Webber and Bartlett, 1977). The ratios of the observed versus the predicted 2-year and 5-year flood peaks (R_2 and R_5) were then calculated. The results of these calculations are presented in table 3.

Table 2.--Annual peak discharges for sites studied

Station number	Station name	Geographical area	Drainage area (mi^2)	Annual peak discharge in ft^3/sec				
				[a]1978	1979	1980	1981	1982
03110980	Consol Run at Bloomingdale	5	0.04	14	8.2	17	6.5	4.4
03111450	Branson Run at Georgetown	5	1.31	134	33	88	69	73
03111455	S. Fork Short Creek at Georgetown	5	10.9	360	205	390	242	[b]170
03111470	Lt. Piney Fork at Parlett	5	1.57	220	44	140	44	39
03111490	Piney Fork Trib. near Piney Fork	5	.44	73	13	13	24	[b]10
03111540	Sloan Run Trib. near Harrisville	2	.34	180	60	161	159	42
03114240	Wood Run near Woodsfield	2	.53	64	92	[b]155	240	[b]30
03115280	Trail Run near Antioch	2	5.45	480	854	470	2,020	390
03115410	Graham Run near Bloomfield	2	.13	6.6	79	26	39	22
03115510	Moss Run near Wingett	2	[c]1.52	170	195	760	155	177
03115710	Buffalo Run Trib. near Dexter City	2	.19	38	45	53	46	[b]32
03125450	Robinson Run near Hendrysburg	5	1.97	147	132	125	125	80
03127950	Clear Fork near Jewett	5	5.45	300	255	267	210	168
03128650	Mud Run Trib. at Wainwright	5	.55	11	22	17	38	15
03158220	Glen Run near Doanville	2	1.09	40	140	195	250	[b]80

Table 2.--Annual peak discharges for sites studied--Continued

Station number	Station name	Geographical area	Drainage area (mi^2)	Annual peak discharge in ft^3/sec				
				[a]1978	1979	1980	1981	1982
03159450	Mill Creek near Chauncey--------------	2	1.48	55	210	[b]200	210	250
03201550	Starr Run near New Plymouth----------	2	.30	24	40	34	94	85
03205995	Sandusky Creek near Burlington-------	2	.73	75	220	[b]112	48	37
03235080	Bull Creek near Adelphi---------------	3	3.13	170	450	510	655	400
03236090	S. Br. Little Salt Creek near Jackson----	3	1.28	420	190	555	[b]195	57
03237095	Devers Run at Lucasville------------	3	1.22	218	219	189	171	330
03272695	Trippetts Branch at Camden-------------	3	.33	28	76	140	120	47
04183750	Racetrack Run at Hicksville------------	4	.34	25	20	42	173	82
04184750	Spring Creek at Fayette---------------	4	2.58	290	100	220	179	395
04184760	Bean Creek Trib. near Fayette----------	4	.56	51	49	63	67	[b]100
04185150	Beaver Creek Trib. near Montpelier-------	4	.40	60	80	141	140	[b]180
04185945	Auglaize River Trib. near Spencerville-----	4	.51	56	74	107	169	136
04187945	Rattlesnake Creek near Cairo-----------------	4	1.45	[b]94	[b]169	160	[b]310	[b]120
04190350	Lt. Auglaize River Trib. at Ottoville----------	4	1.04	[b]70	[b]60	[b]60	[b]125	[b]150
04191480	Beetree Run near Junction--------------	4	1.66	[b]45	[b]100	[b]78	139	13

[a]Peaks prior to 1978:

Station number	Year	Peak (in ft^3/s)
03158220	1977	175
03235080	1977	550
03236090	1975	490
04191480	1977	108

[b]Estimated

[c]Revised

Table 3.--Comparison of observed and predicted flood peaks

[S, More than 40 percent surface mined; C, Less than 40 percent surface mined and less than 20 percent forested; SF, Less than 40 percent surface mined and more than 20 percent forested; F, More than 20 percent forested; and N, Northwestern Ohio]

USGS station number	Station name	Area	Type of site	Observed Q_2	Predicted Q_2	R_2	Observed Q_5	Predicted Q_5	R_5
03110980	Consol Run at Bloomingdale----------	5	S	7.5	15	0.50	18	31	0.58
03111450	Branson Run at Georgetown-----------	5	S	74	131	.56	116	237	.50
03111455	S. Fk. Short Cr. at Georgetown------	5	S	232	507	.46	428	841	.51
03111470	Lt. Piney Fork at Parlett-----------	5	S	65	142	.46	205	254	.81
03111490	Piney Fork Trib. near Piney Fork----	5	S	17	62	.27	51	117	.44
03111540	Sloan Run Trib. near Harrisville----	2	C	71	62	1.15	206	148	1.22
03114240	Wood Run near Woodsfield------------	2	F	73	88	.83	245	210	1.17
03115280	Trail Run near Antioch--------------	2	F	600	457	1.31	1,500	978	1.53
03115410	Graham Run near Bloomfield----------	2	F	26	30	.87	65	71	.92
03115510	Moss Run near Wingett---------------	2	SF	176	173	1.02	222	374	.59
03115710	Buffalo Run Trib. near Dexter City--	2	SF	39	42	.93	52	105	.50
03125450	Robinson Run near Hendrysburg-------	5	S	126	180	.70	142	322	.44
03127950	Clear Fork near Jewett--------------	5	S	218	337	.65	320	579	.55
03128650	Mud Run Trib. at Wainwright---------	5	SF	17	68	.25	33	126	.26
03158220	Glen Run near Doanville-------------	2	SF	152	127	1.20	225	266	.85
03159450	Mill Creek near Chauncey------------	2	F	200	156	1.28	240	322	.75
03201550	Starr Run near New Plymouth---------	2	SF	37	52	.71	84	116	.72

Table 3.--Comparison of observed and predicted flood peaks--Continued

USGS station number	Station name	Area	Type of site	Observed Q_2	Predicted Q_2	R_2	Observed Q_5	Predicted Q_5	R_5
03205995	Sandusky Creek near Burlington-------	2	F	65	98	.66	200	212	.94
03235080	Bull Creek near Adelphi--------------	3	F	445	423	1.05	615	743	.83
03236090	S. Br. Little Salt Cr. nr. Jackson---	3	F	233	320	.73	520	564	.92
03237095	Devers Run at Lucasville-------------	3	F	208	464	.45	300	810	.37
03272695	Trippetts Branch at Camden-----------	3	F	56	82	.68	185	155	1.19
04183750	Racetrack Run at Hicksville----------	4	N	38	23	1.65	150	39	3.85
04184750	Spring Creek at Fayette--------------	4	N	170	103	1.65	470	164	2.87
04184760	Bean Creek Trib. near Fayette--------	4	N	58	31	1.87	89	52	1.71
04185150	Beaver Creek Trib. near Montpelier---	4	N	90	30	3.00	177	49	3.61
04185945	Auglaize River Trib. nr. Spencerville	4	N	83	44	1.89	171	68	2.51
04187945	Rattlesnake Creek near Cairo---------	4	N	135	80	1.69	284	125	2.27
04190350	Lt. Auglaize River Trib. at Ottoville	4	N	74	56	1.32	131	90	1.46
04191480	Beetree Run near Junction------------	4	N	98	48	2.04	178	82	2.17

Surface-Mined Sites

Several relationships are evident in the R_2 and R_5 values for surface-mined sites. Thirteen sites have some surface-mined land in their drainage basins. The R_2 values for these sites range from 0.25 to 1.20 and average 0.68. Only three sites have R_2 values above 1.00 (fig. 2). The R_5 values for the same sites range from 0.26 to 1.22 and average 0.61. Only one site has an R_5 value above 1.00 (fig. 3).

The ratios are even lower when only the seven sites that are more than 40 percent surface mined are considered. The R_2 values range from 0.27 to 0.70 and average 0.51. The R_5 values range from 0.44 to 0.81 and average 0.55. This indicates that observed flood peaks are lower by a significant amount in surface-mined areas compared to unmined areas from which published flood equations have been developed.

A time-bias analysis supports the premise that the reduced flood peaks at surface-mined sites are not due to climatic conditions. Ten long-term gage sites in southern and eastern Ohio were analyzed as if they were crest-stage gages; annual peaks for 1977-82 were plotted on log probability paper and a 2-year and 5-year flood peak was determined for each station. The prediction equations were then used to determine a 2-year and 5-year flood peak from basin characteristics. The R_2 values average 1.01 and range from 0.47 to 1.44 (fig. 4). The R_5 values average 1.14 and range from 0.58 to 2.39 (fig. 5). Comparing the observed values with published flood-frequency values from Bulletin 45, similar results were obtained. The R_2 values range from 0.65 to 1.20 and average 0.90. The R_5 values range from 0.68 to 1.82 and average 1.01. Because these values scatter fairly regularly around an equality line, no time bias is indicated for surface-mined sites.

Rainfall in southern and eastern Ohio during the study period was significantly above normal. In the years 1977-81, rainfall was above normal every year at New Philadelphia and Senecaville Lake, and above normal three of the five years at Carpenter (fig. 1). The averages for these five years were 15 percent, 17 percent, and 3 percent above normal, respectively (U.S. Department of Commerce, 1977-81). Therefore, the reduced flood peaks at surface-mined sites probably are not due to rainfall conditions.

Forested Sites

The existing equations estimate the flood peaks for forested sites fairly well. Nine sites have more than 20 percent forested land and no surface-mined land in their drainage basins. The R_2 values range from 0.45 to 1.31 and average 0.87; three sites have R_2 values over 1.00 (fig. 6). The R_5 values range from 0.38 to 1.53 and average 0.96; three sites have R_5 values over 1.00 (fig. 7).

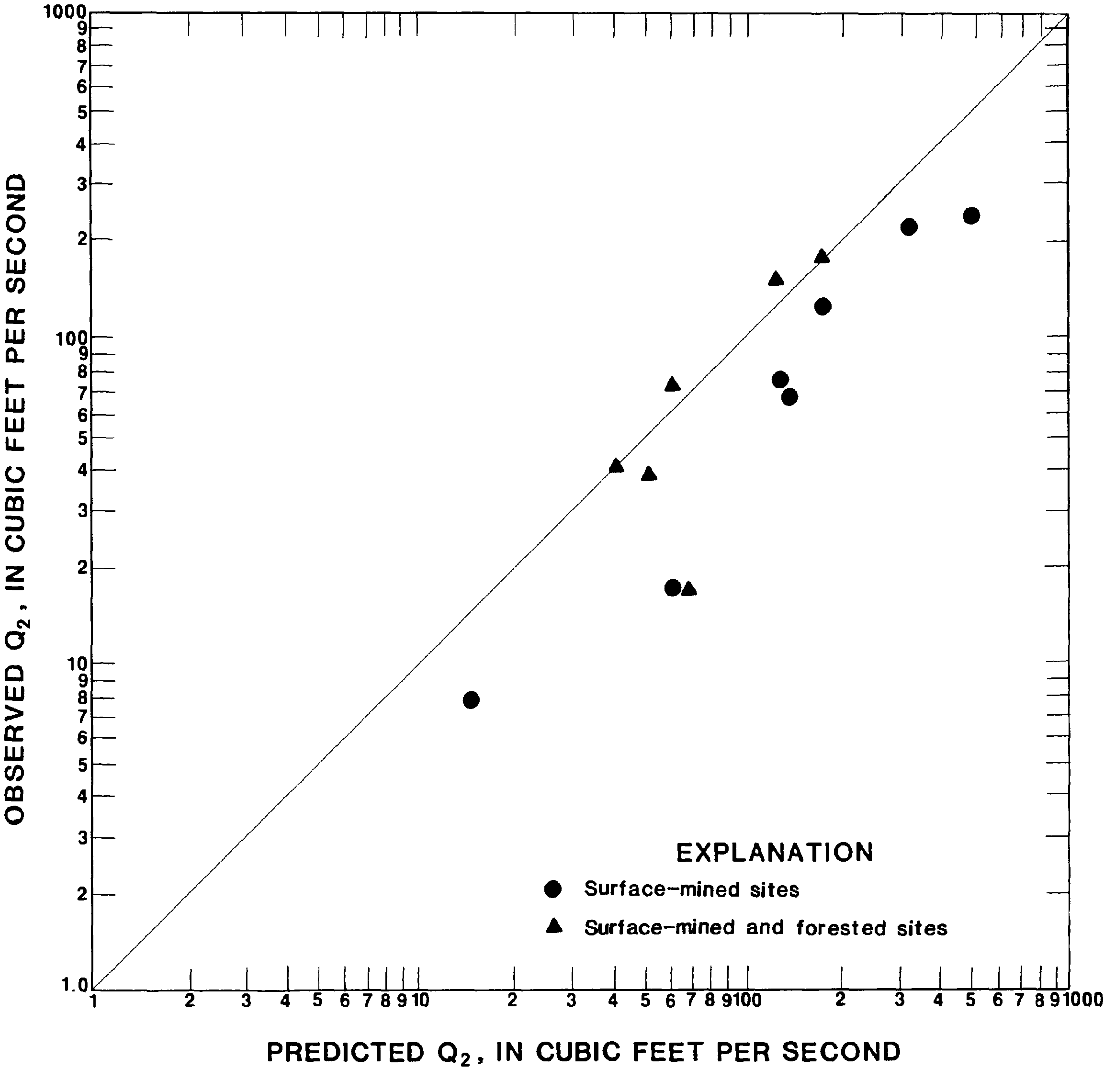

Figure 2.--Observed versus predicted Q_2 for surface-mined sites.

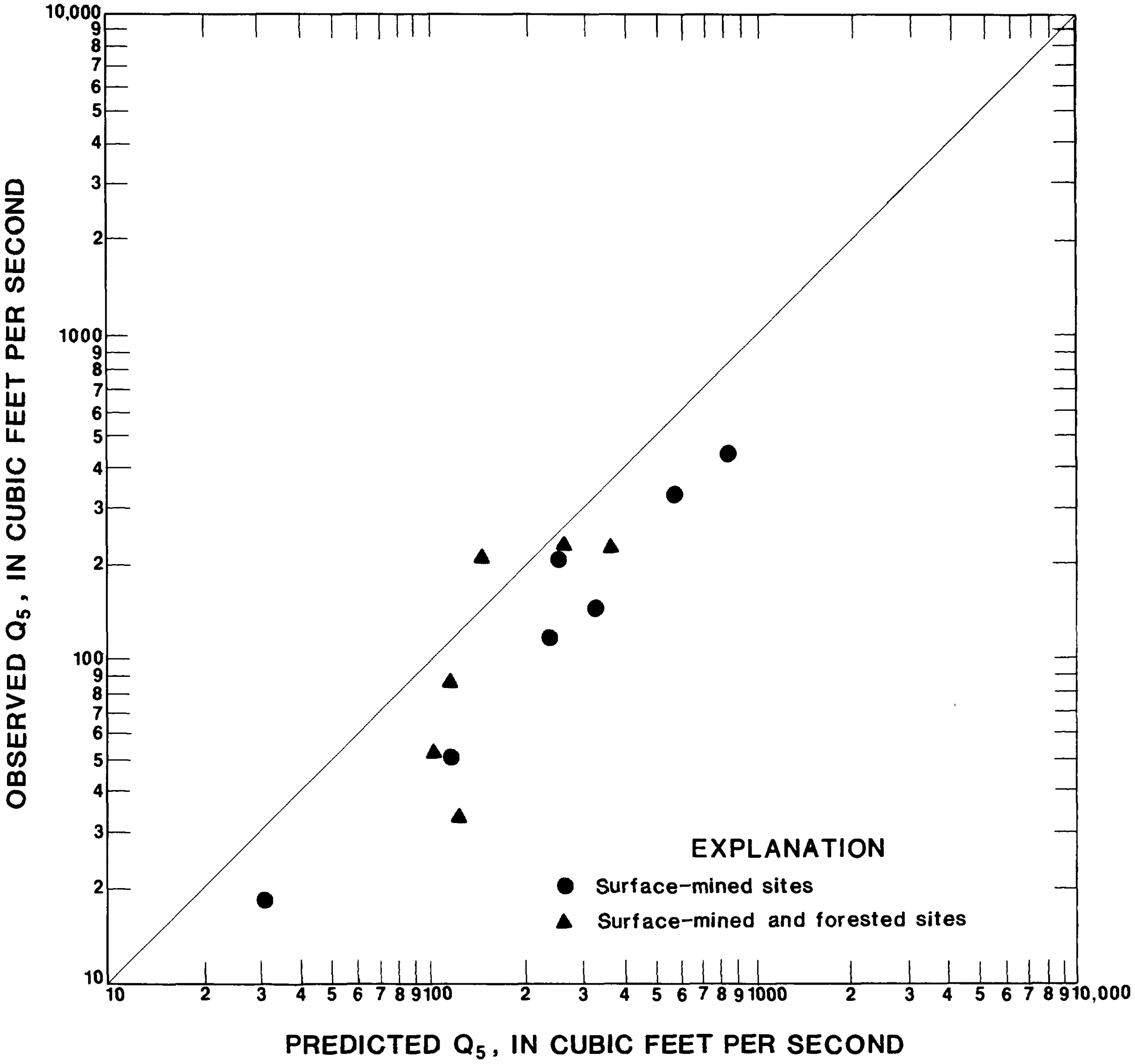

Figure 3.--Observed versus predicted Q_5 for surface-mined sites.

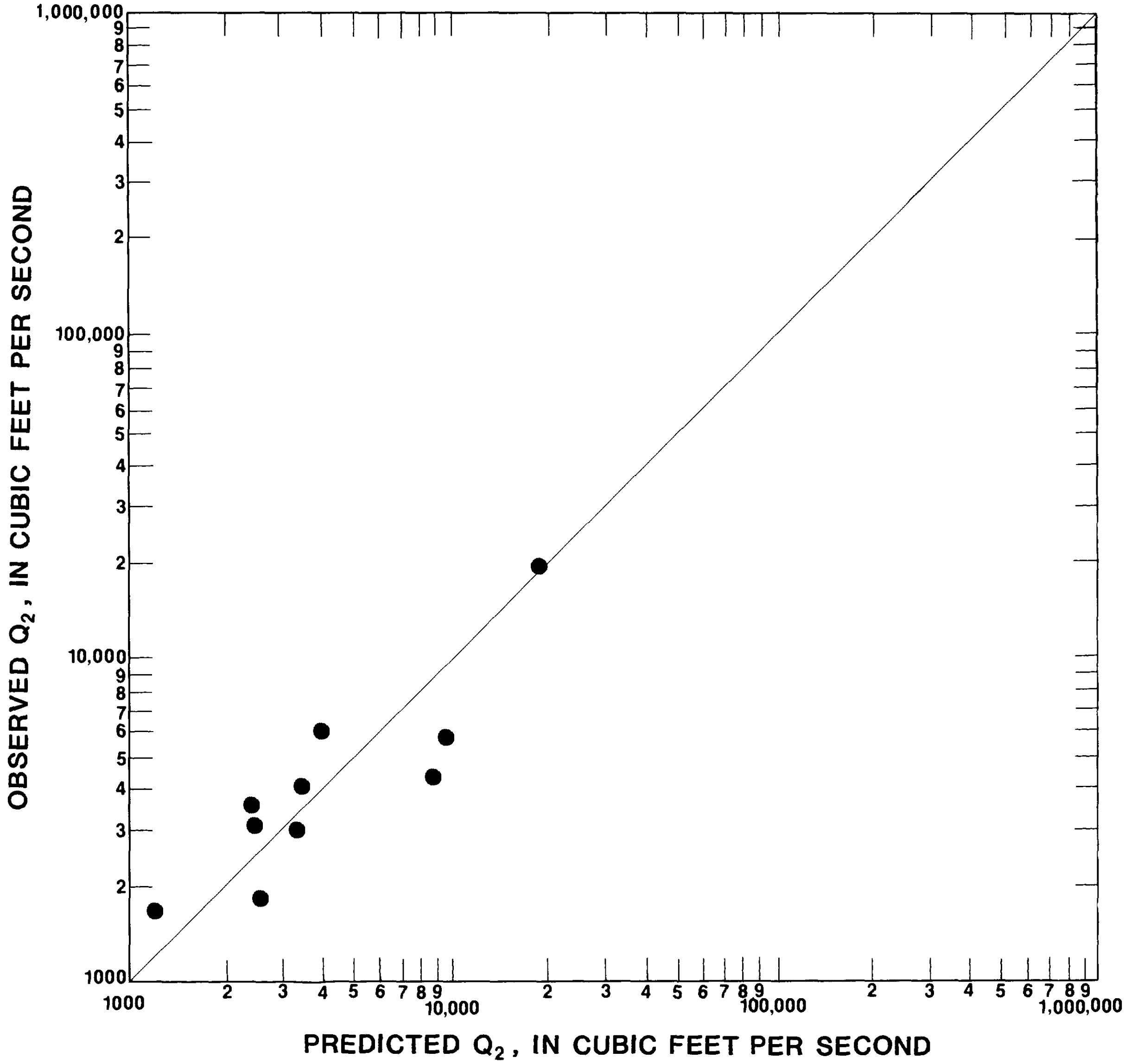

Figure 4.--Observed (1977-82 water years) versus predicted Q_2 for southeastern Ohio long-term stations.

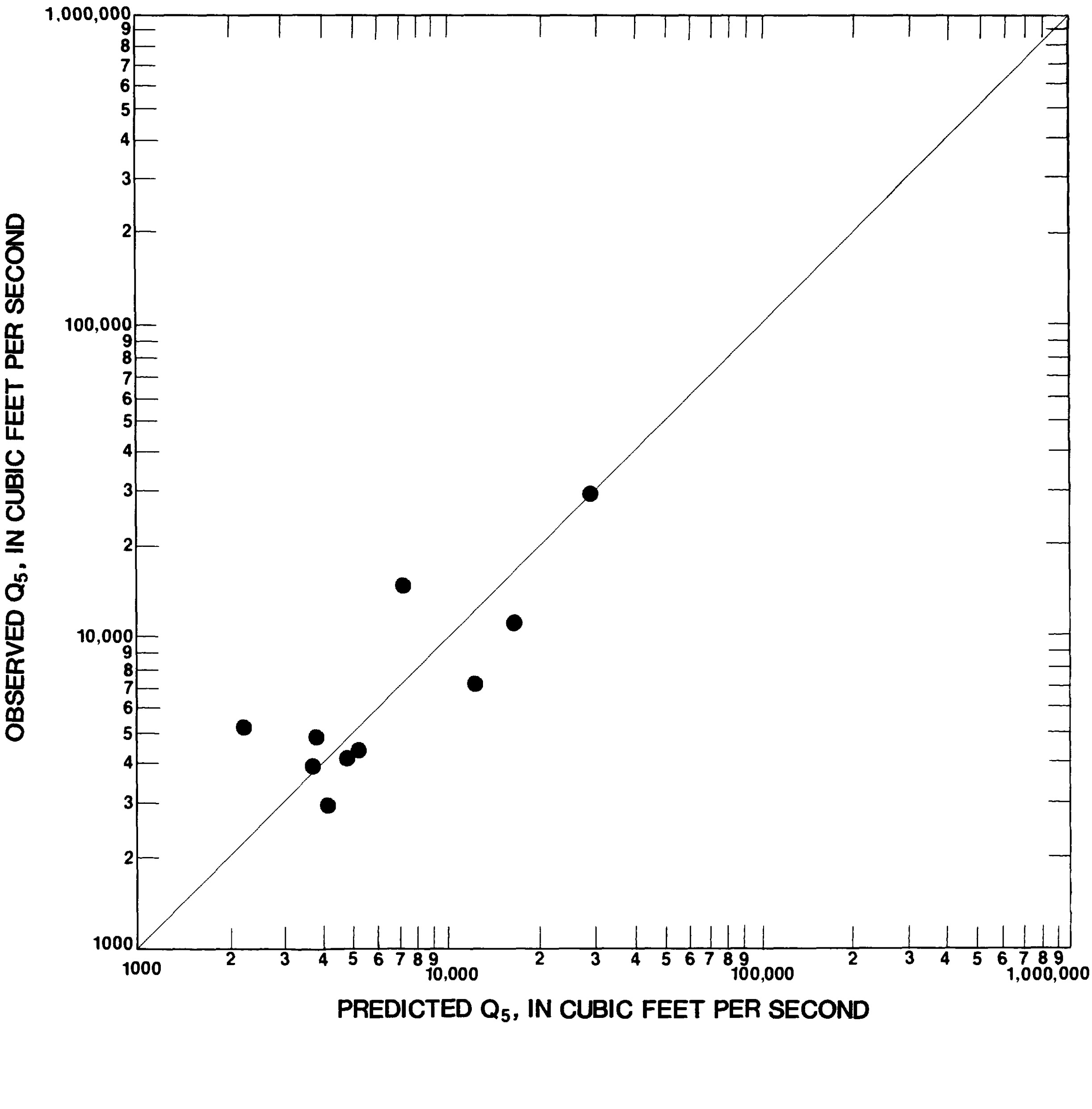

Figure 5.--Observed (1977-82 water years) versus predicted Q_5 for southeastern Ohio long-term stations.

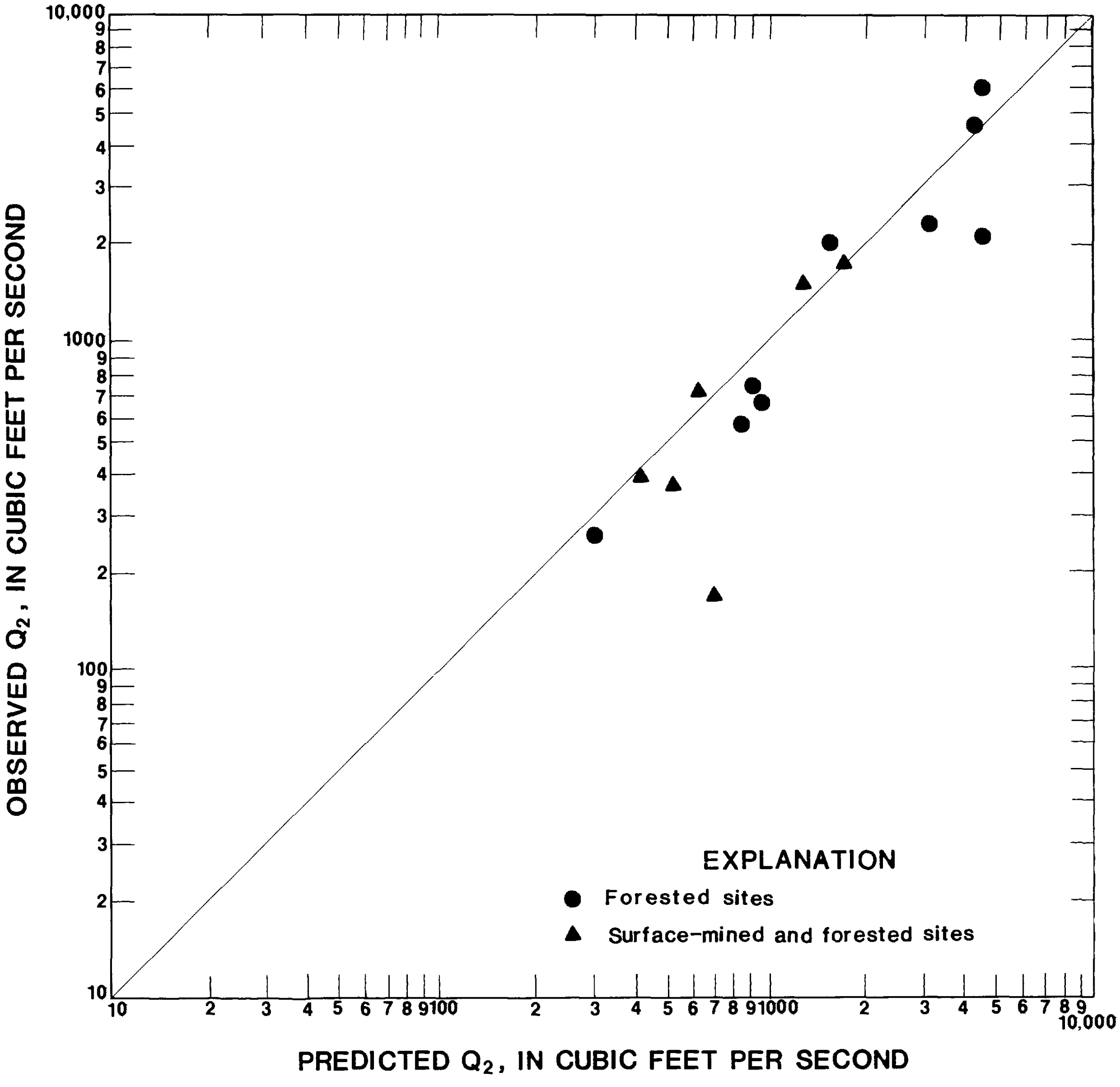

Figure 6.--Observed versus predicted Q_2 for forested sites.

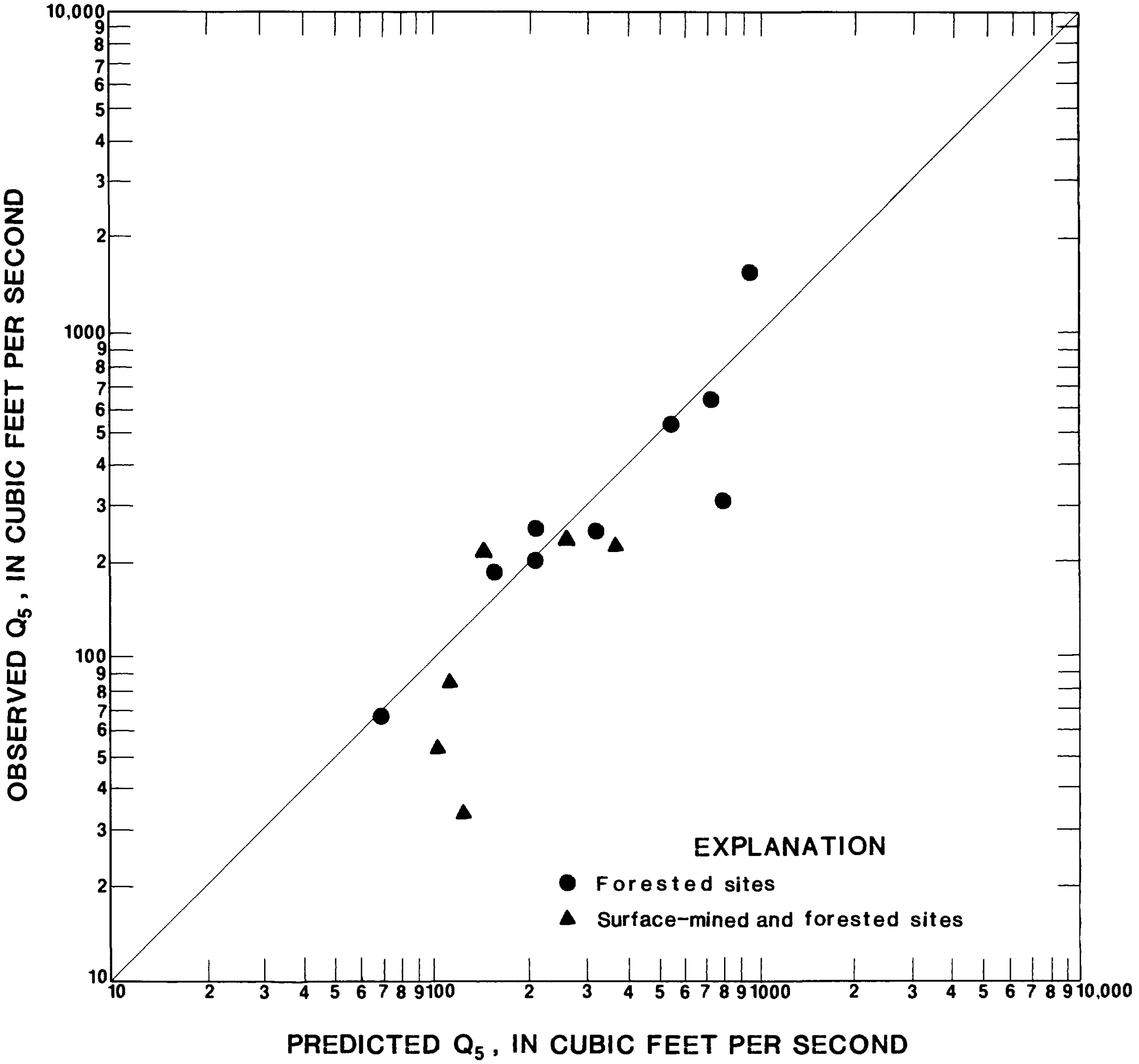

Figure 7.--Observed versus predicted Q_5 for forested sites.

Five additional sites also were considered, each of which has more than 20 percent forest cover but also has some surface-mined land. When these are combined with the other forested sites, the R_2 values range from 0.25 to 1.31 and average 0.86; five sites have R_2 values over 1.00. The R_5 values range from 0.26 to 1.53 and average 0.82; three sites have R_5 values over 1.00.

The variations of R_2 and R_5 averages indicate that the equations developed by Webber and Bartlett (1977) predict flood peaks from forested areas fairly well. The amount of forest in a basin does not seem to have much effect on flood peaks. The precipitation information and the bias analysis mentioned earlier are applicable to the forested sites as well. The flood peaks do not appear to be affected by the average rainfall over the study period.

Northwestern Ohio Sites

Published equations underestimate flood peaks for the eight northwestern sites. The R_2 values range from 1.32 to 3.00 and average 1.89 (fig. 8). The R_5 values range from 1.46 to 3.85 and average 2.56 (fig. 9). This shows that observed flood peaks have been higher than those predicted by equations published in Bulletin 45.

A time-bias analysis was performed by taking the annual flood peaks from six long-term gaging stations in the area and treating these data in the same manner as the crest-stage data were treated. R_2 values from this analysis range from 0.80 to 1.99 and average 1.45 (fig. 10). R_5 values range from 1.07 to 2.62 and average 1.80 (fig. 11). This indicates that observed flood peaks in northwestern Ohio are significantly higher than results obtained from equations published in Bulletin 45.

Observed values from the study period, 1977-82, also were compared with the long-term flood-peak values (obtained from log-Pearson Type III analyses) published in Bulletin 45. These comparisons indicate that the observed values during the 1977-82 period are slightly higher than the long-term values. R_2 values range from 1.00 to 1.45 and average 1.25 (fig. 12). R_5 values range from 1.22 to 1.85 and average 1.48 (fig. 13). All of these values are lower than the averages found for the eight northwestern crest-stage sites; however, it appears that the study period did have higher than normal flood peaks. The average rainfall at Montpelier and Defiance (fig. 1) was 12 percent and 10 percent above normal, respectively, for the years 1977-81. At St. Marys, which is at the southern edge of the northwestern study area (fig. 1), the rainfall for 1977-81 was 6 percent below normal.

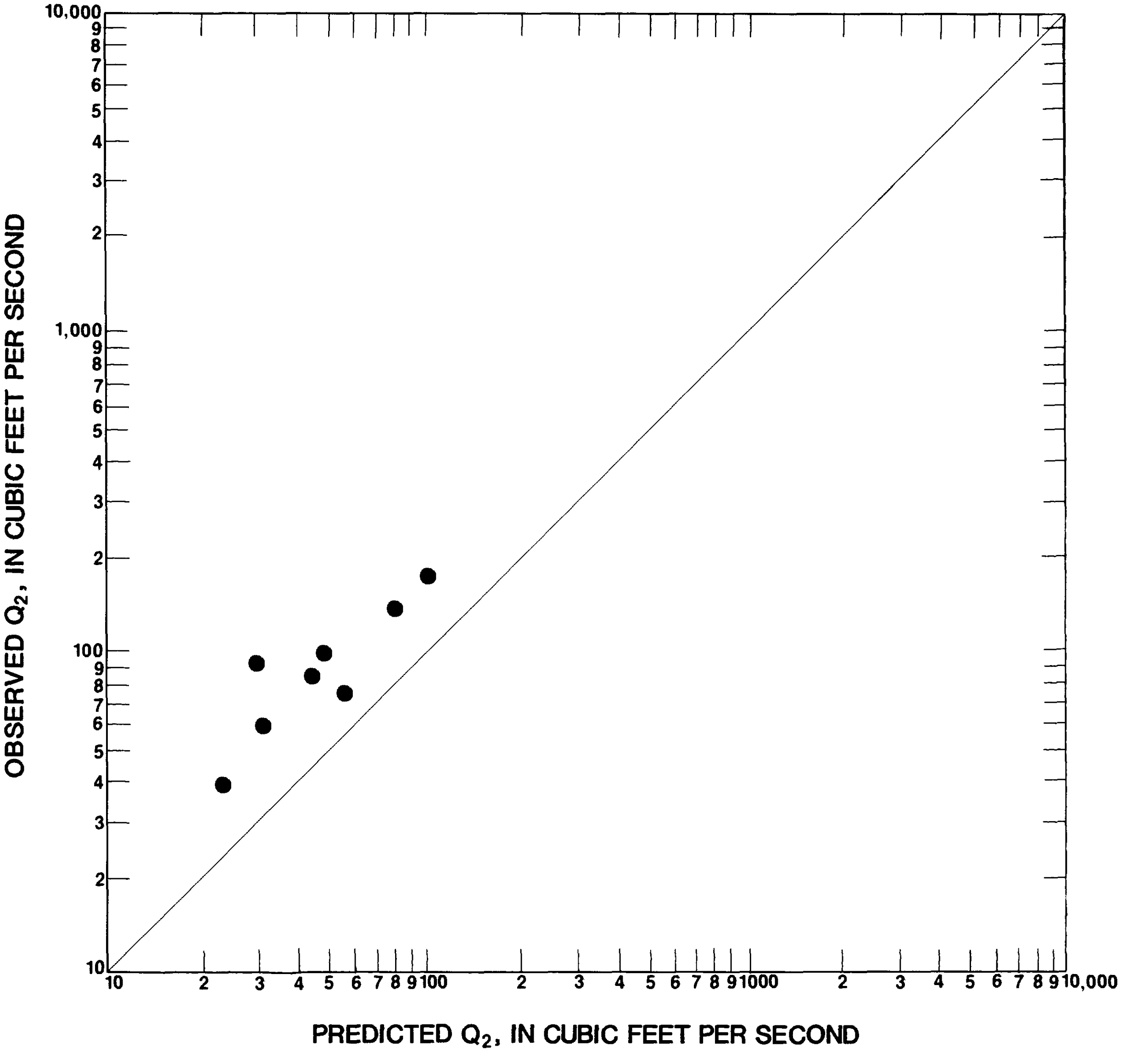

Figure 8.--Observed versus predicted Q_2 for northwestern Ohio sites.

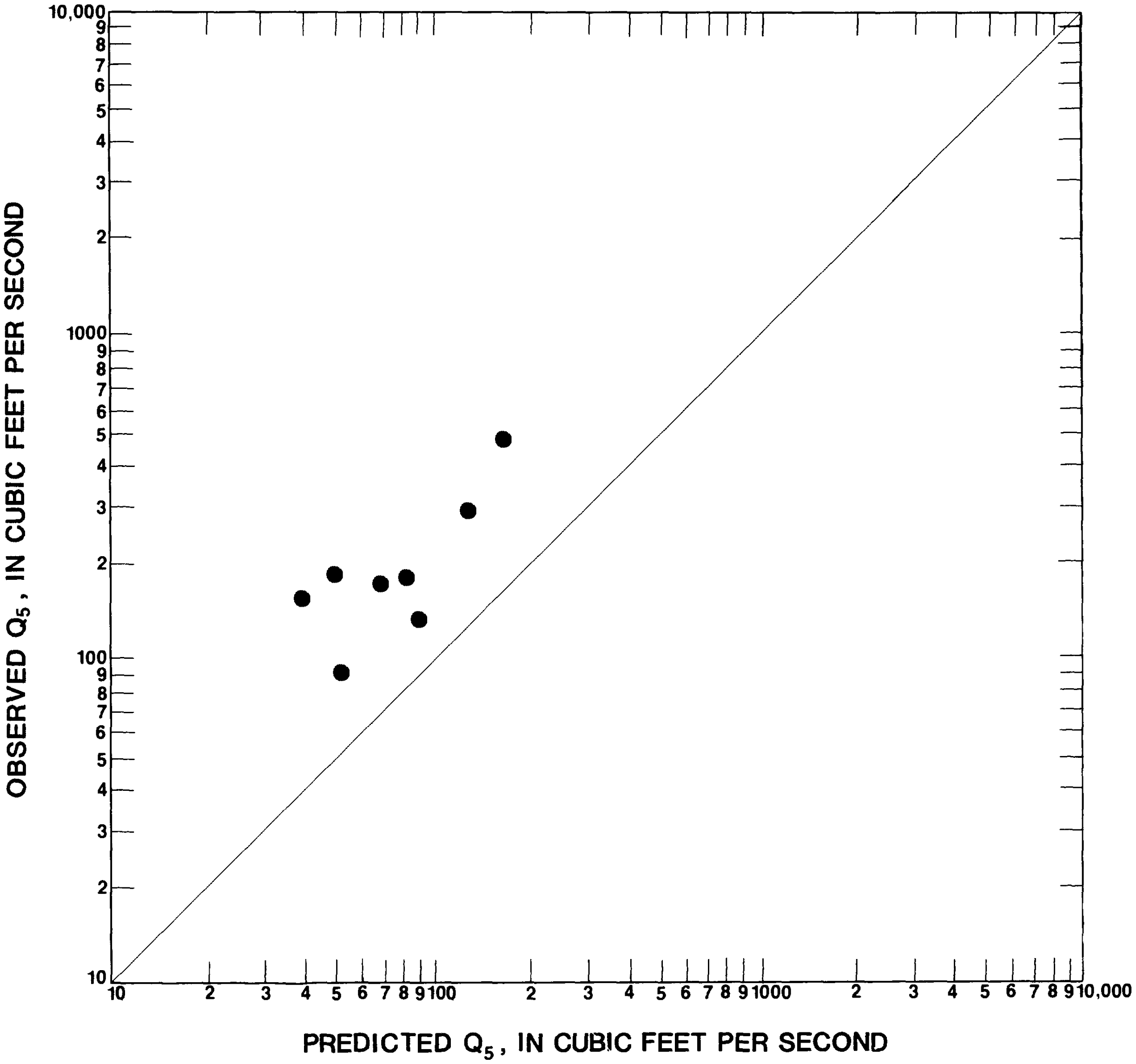

Figure 9.--Observed versus predicted Q_5 for northwestern Ohio sites.

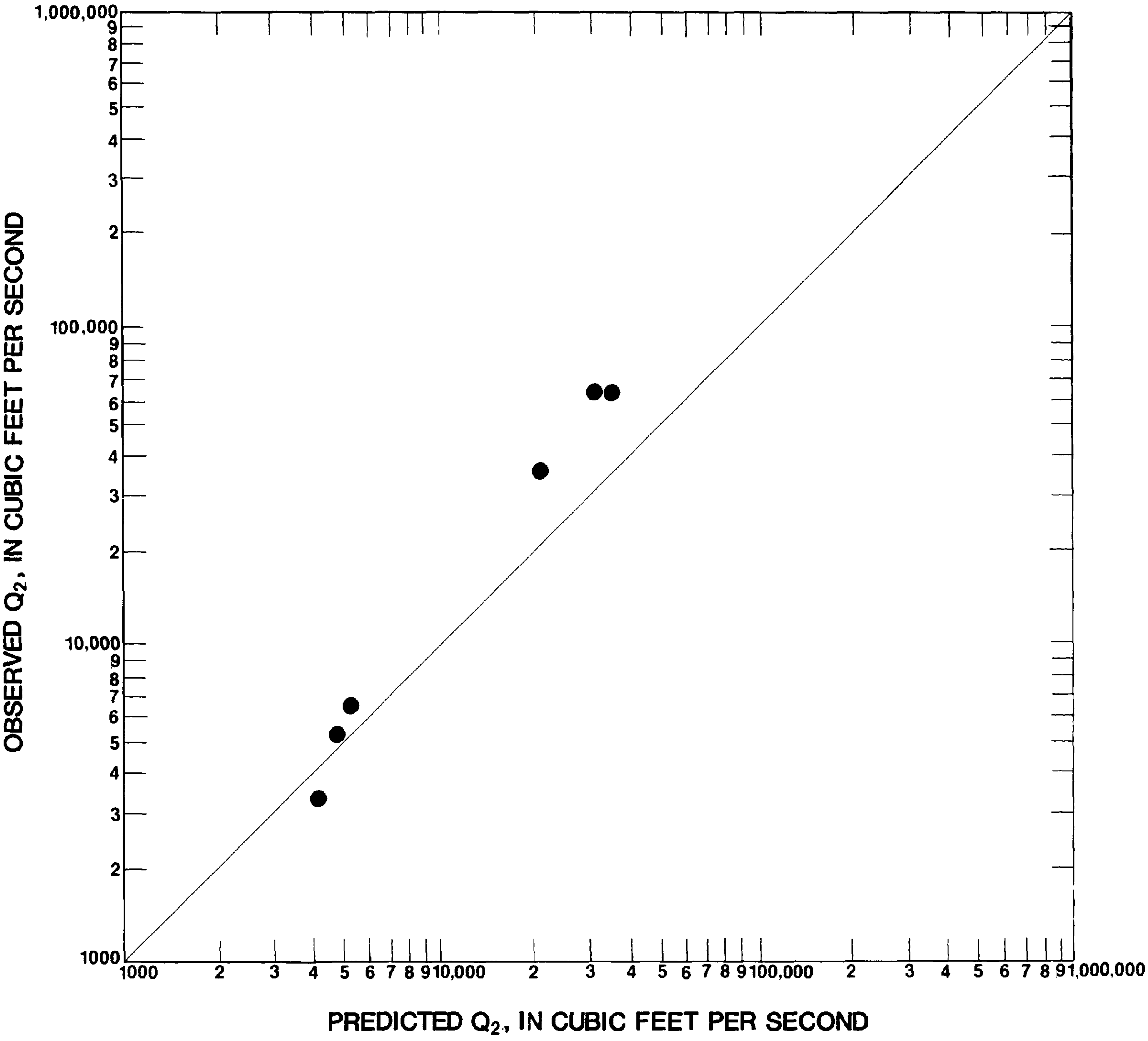

Figure 10.--Observed (1977-82 water years) versus predicted Q_2 for long-term stations in northwestern Ohio.

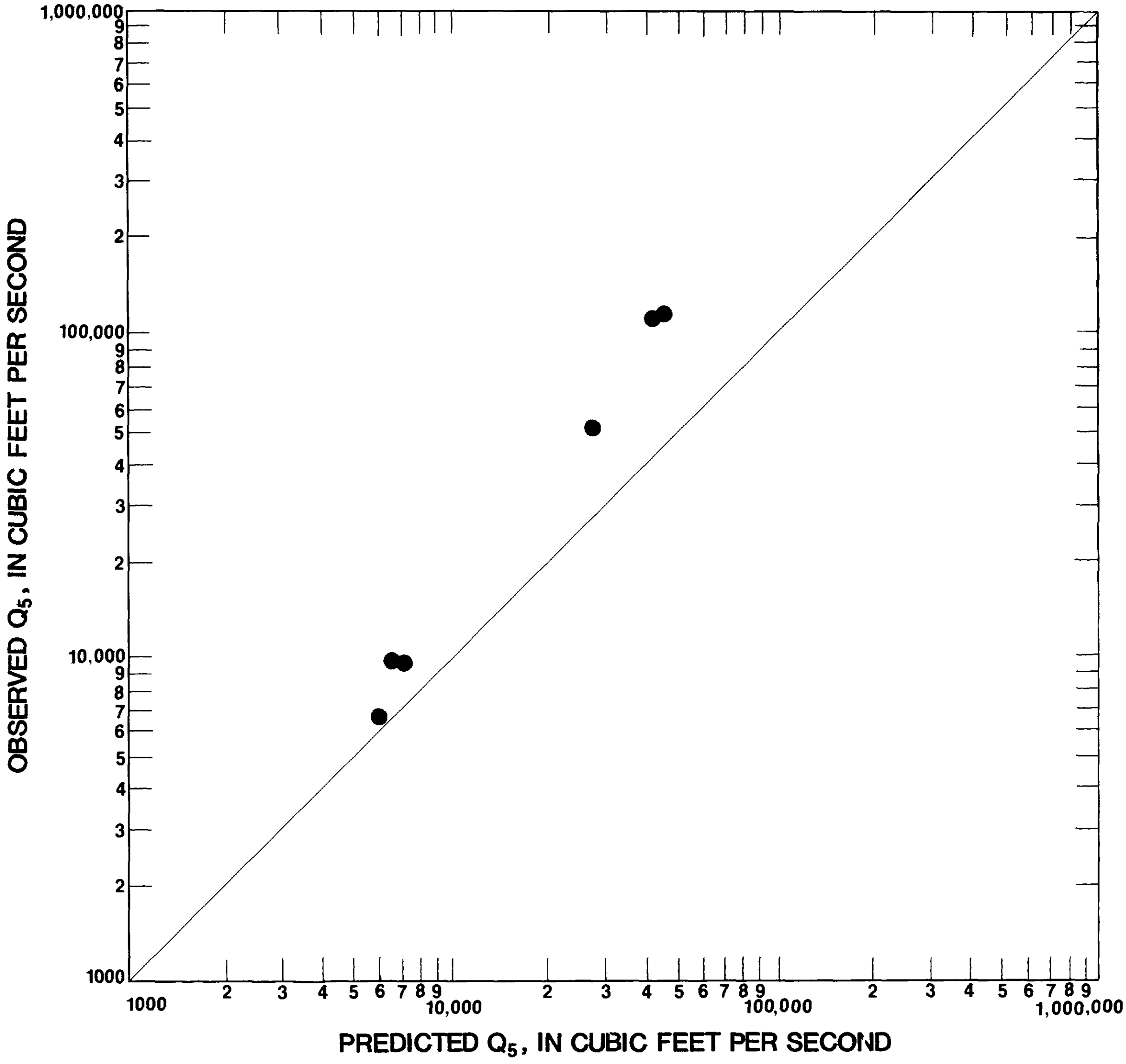

Figure 11.--Observed (1977-82 water years) versus predicted Q_5 for long-term stations in northwestern Ohio.

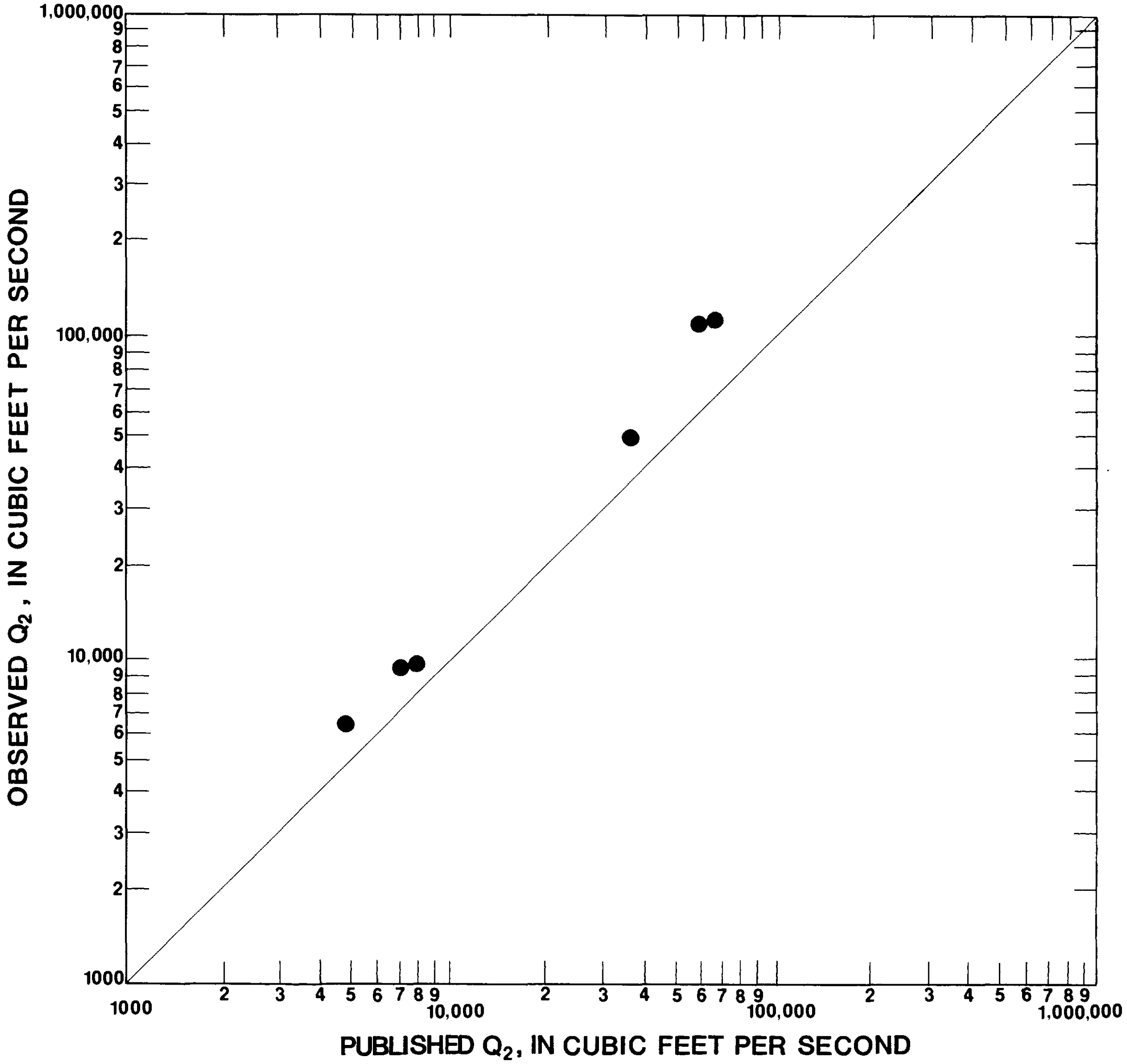

Figure 12.--Observed (1977-82 water years) versus published Q_2 for long-term stations in northwestern Ohio.

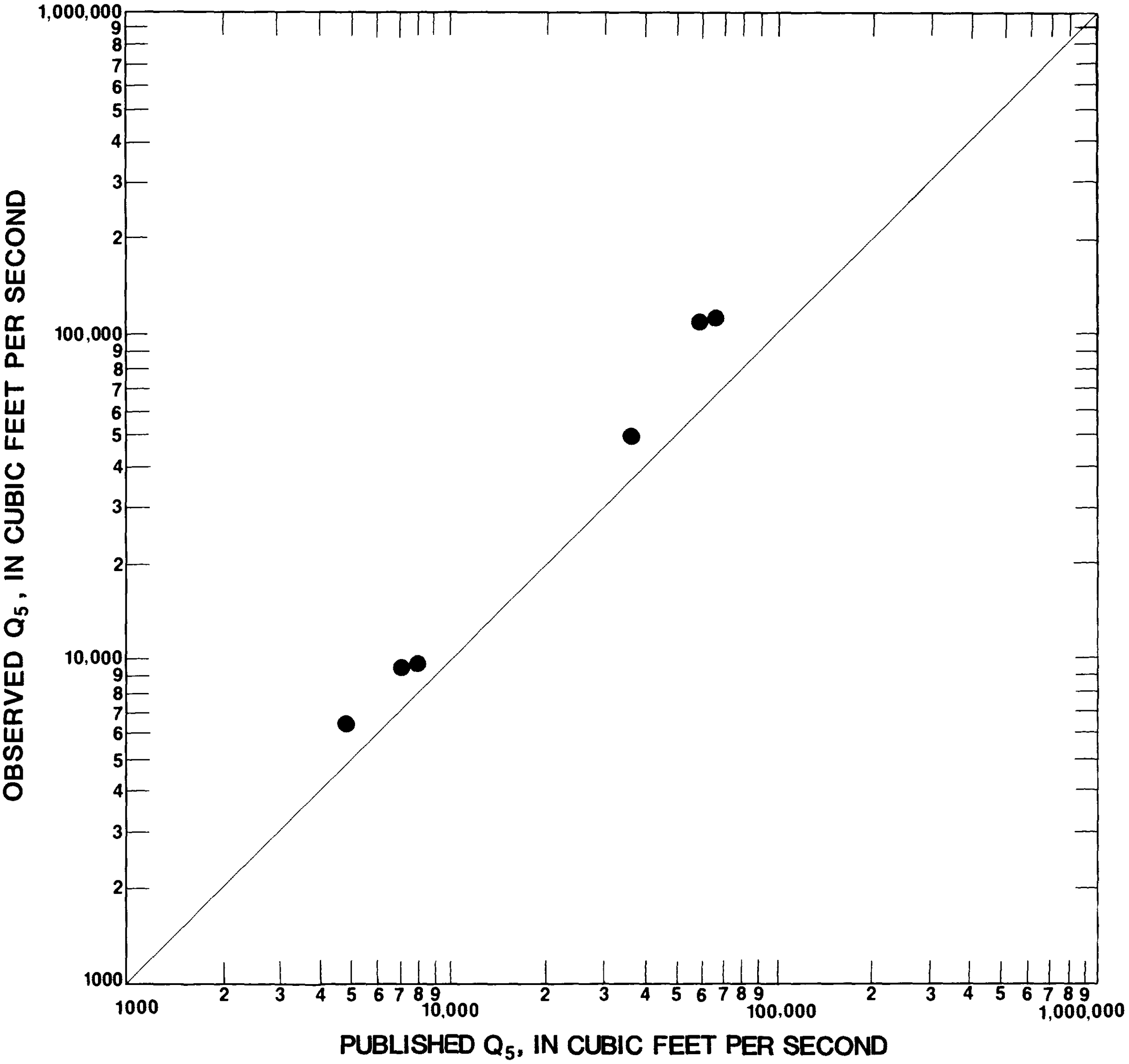

Figure 13.--Observed (1977-82 water years) versus published Q_5 for long-term stations in northwestern Ohio.

DEVELOPMENT OF NEW REGRESSION EQUATIONS FOR PREDICTING FLOOD PEAKS

Peak discharges for the 2-year (Q_2) and 5-year (Q_5) recurrence intervals were used as dependent variables in a step-forward multiple regression analysis. The 30 sites were divided into 4 groups. The first group consisted of sites where more than 40 percent of the basin is surface mined. The second group was made up of sites where any part of the basin is surface mined. The third group was composed of sites where more than 20 percent of the basin is forested. The fourth group was the eight northwestern sites. The independent variables were derived from WATSTORE basin characteristics (Dempster, 1982) as follows:

-- Drainage area, in square miles.
-- Main channel slope, in feet per mile.
-- Stream length, in miles.
-- Average of channel elevations, in feet above sea level (elev. 10-85), divided by 1,000.
-- Surface storage area, in percent, plus 1.0 percent.
-- Forested area, in percent, plus 1.0 percent.
-- Mean annual precipitation, in inches minus 27 (corrected for mean annual evapotranspiration).
-- Precipitation intensity ($I_{24,2}$), 24-hour rainfall expected on the average once each 2 years, in inches.
-- Mean minimum January temperature, in degrees Fahrenheit.
-- Surface-mined area, in percent, plus 1.0.

The preliminary regression analyses seem to indicate that new equations can be developed to estimate flood peaks for surface-mined and small northwestern Ohio basins after a longer period of data collection. The preliminary regression equations have standard errors equal or smaller than the equations published in Webber and Bartlett (1977). The preliminary regression equation developed for forested basins may or may not have smaller standard errors than the existing published equations. The new regression equations will not be finalized or published until the project is completed.

All of the regression analyses are based on dependent variables defined with only 5 or 6 years of data. When data collection for the project is completed, each frequency analysis (used to define dependent variables) will be based on 10 or 11 years of data. The resulting dependent variables should be more reliable than those used in this preliminary regression analysis.

FUTURE STUDIES

Annual peak discharges will be collected for an additional 5 years at all 30 sites. Basin characteristics will be reexamined to determine any changes that might have occurred during the study. The regression analysis will be conducted again and final equations for estimating flood magnitude and frequency will be developed.

CONCLUSIONS

Annual peak discharges have been documented at all 30 sites for the 1978-82 water years and for an additional year at 4 other sites. Basin characteristics for all sites were computed for 1978 conditions. Aerial photographs also were obtained to document these 1978 surface-mining and forested conditions.

Preliminary data analyses indicate that the existing flood-discharge equations may need modification in areas of surface mining and in small drainage basins in northwestern Ohio. Existing equations overestimate flood peaks in surface-mined areas when compared with the observed values from sites in these areas. The existing equations underestimate flood peaks at sites in northwestern Ohio when compared with the observed values. This may be partially due to a higher-than-normal amount of rainfall during the study period. Existing equations estimate flood peaks from forested basins with no surface mining fairly well.

Preliminary regression analyses indicate that flood-peak equations can be developed for surface-mined areas and for small drainage basins in northwestern Ohio. These equations will not be finalized until the project is completed. Until that time, the equations from Bulletin 45 should be used with caution.

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