ESTIMATION OF FLOOD PEAKS FROM CHANNEL CHARACTERISTICS IN OHIO

By Donald K. Roth

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CONVERSION FACTORS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
inch (in)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
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)

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ABSTRACT

Regression equations were developed to estimate flood peaks with selected recurrence intervals of 2 to 100 years for Ohio streams with alluvial and bedrock channels. Channel-geometry characteristics, rather than basin characteristics, were used as independent variables. Width of active channel was the only channel-geometry characteristic significant at the 5-percent level in the estimating equations for alluvial channels. Standard errors of estimate for those equations range from 42 percent for the 2-year flood peak to 55 percent for the 100-year flood peak. The equations were developed from data collected at 142 gaging stations that have active-channel widths ranging from 2 to 495 feet.

For streams with bedrock or firm channels, depth of the bankfull channel and active-channel width were statistically significant characteristics at the 5-percent level for all but the 2-year recurrence interval flood-peak equation, for which only active-channel width was statistically significant. Standard errors of estimate range from 33 percent for the 5-year flood peak to 40 percent for the 100-year flood peak when both significant variables are included in the equations. Standard errors of estimate range from 36 percent to 46 percent when only the active-channel width independent variable is used. These equations are based on channel-geometry data collected at 20 gaging stations that have active-channel widths ranging from 14 to 240 feet and average bankfull-channel depths ranging from 2.5 to 9.2 feet.

Channel-geometry characteristics also were measured at 168 ungaged sites to provide information that can be used to better define the geographic-area boundaries in three areas of Ohio where the boundaries were previously defined in a flood magnitude and frequency report.

INTRODUCTION

Background

Rapid and reliable techniques for estimating floodflow characteristics are needed by designers and planners in the design of dams, bridges, culverts, canals, floodways, and other structures. Flood data are also used for determining flood insurance rates, for regulatory activities, and for land zoning.

This report supplements a previous study of floodflow as it relates to channel geometry in Ohio (Webber and Roberts, 1981). The purpose of the study was to develop a set of flood-peak estimating equations that were independent of traditional basin-characteristic and geographic-area variables. The equations were developed, in part, to improve the definition of geographic-area boundaries (fig. 1) that Webber and Bartlett (1977) had delineated in their comprehensive report on magnitudes and frequencies of floods in Ohio.

Webber and Roberts (1981) presented equations for estimating flood peaks at various recurrence intervals by means of channel characteristics. Four channel-geometry characteristics and two grain-size varibles were the independent variables used in the regression analysis--width and average depth of the active channel (WAC and DAC), width and average depth of the bankfull channel (WBF and DBF), and the percentage of silt and clay in streambed and in streambanks (BEDSC and BANKSC). Only one of the six variables (WAC) was statistically significant at the 5-percent level. Data used in the analysis were collected at 170 Ohio gaging stations on streams whose channels have alluvial bottoms.

Although the previous study was valuable in clarifying geographic-area boundaries in the south-central part of Ohio, difficulties were encountered in trying to clarify the boundaries in other areas of the State. In northern and eastern Ohio, the geographic-area boundaries lie in areas where streams with bedrock channels are common. The equations for estimating flood magnitude developed by Webber and Roberts (1981) are for alluvial channels; to develop equations for bedrock channels was outside the scope of their study.

Purpose and Scope

This report presents the results of a study to (1) determine if the median-grain size of streambed and (or) streambank material can be used to improve the equations developed by Webber and Roberts (1981), (2) develop regression equations that relate flood peaks to channel characteristics for streams having bedrock or firm channel bottoms, and (3) collect channel-characteristic data at ungaged sites in three areas of Ohio where the geographic-area boundaries delineated by Webber and Bartlett (1977) may need to be refined. The three boundary areas in question are shown in figure 1. The actual redefinition of the boundaries is beyond the scope of this report.

The equations developed during this and the previous study by Webber and Bartlett (1977) and discussed in the following sections of the report are not intended to replace the equations developed by Webber and Bartlett, but are offered as a supplemental technique for estimating flood magnitude and frequency at ungaged sites without the use of basin and climatic characteristics.

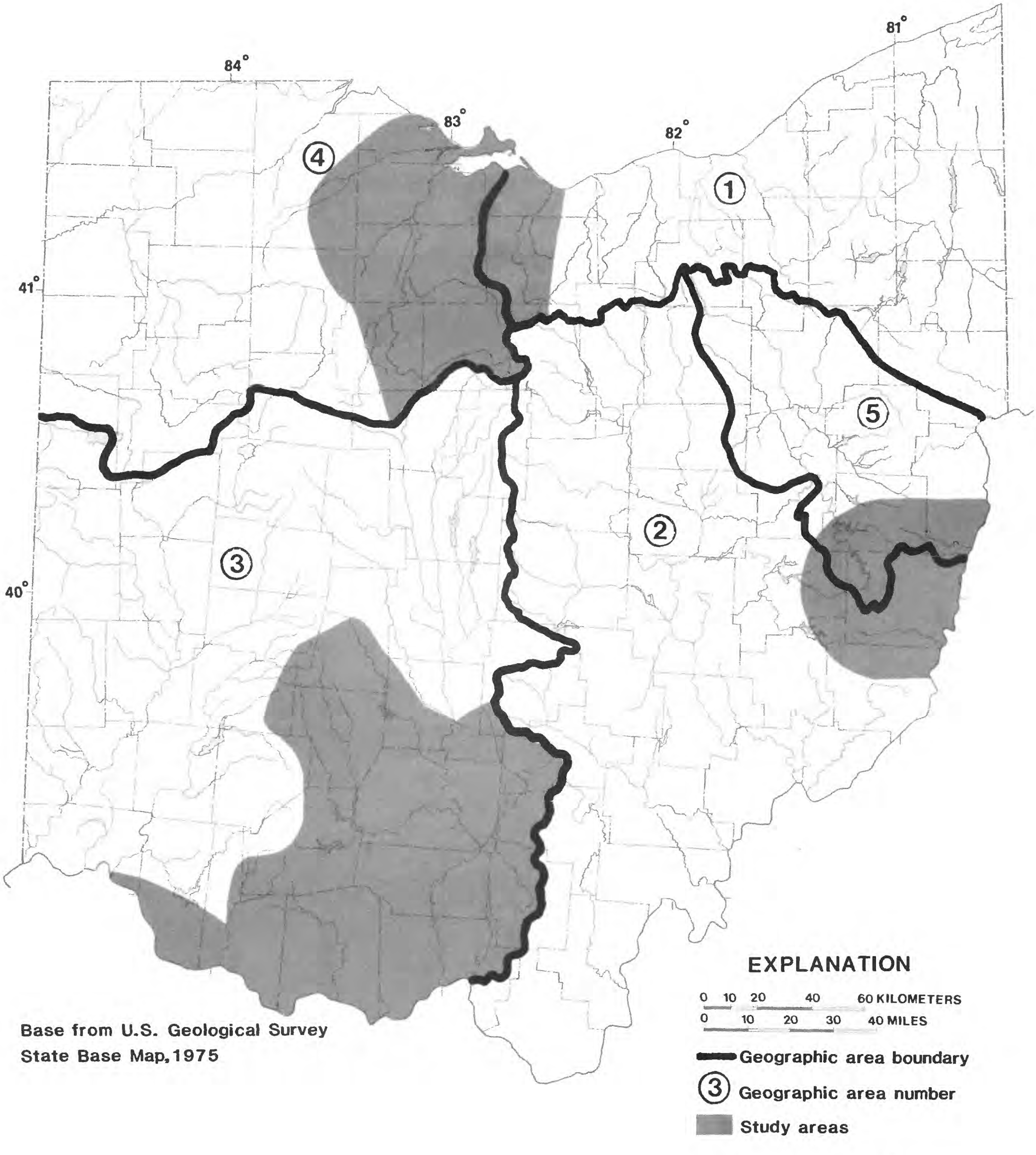


Figure 1.--Study area and geographic areas in Ohio.

Description of Study Area

Ohio is divided into two major river basins--the St. Lawrence River basin, which drains 11,775 square miles of the northern part of the State, and the Ohio River basin, which drains 29,474 square miles of the southern part. The northwestern part of the State is a flat, multiglaciated lakebed region. The southwestern, central, and northeastern parts are rolling till plains and terminal moraines. The southeastern part is hilly and unglaciated. The climate is humid continental, and is characterized by hot summers and fairly cold winters. Annual precipitation ranges from 32 to 44 inches, and is distributed uniformly throughout the year.

Acknowledgments

Numerous individuals and governmental agencies have cooperated over the years to obtain hydrologic data by supporting the U.S. Geological Survey stream-gaging program in Ohio. The chief cooperators in this program have been the Ohio Department of Natural Resources, the Ohio Department of Transportation, and the U.S. Army Corps of Engineers.

Data collection for this particular study began in 1982 and was funded cooperatively by the Ohio Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

CHANNEL DATA USED IN REGRESSION ANALYSIS

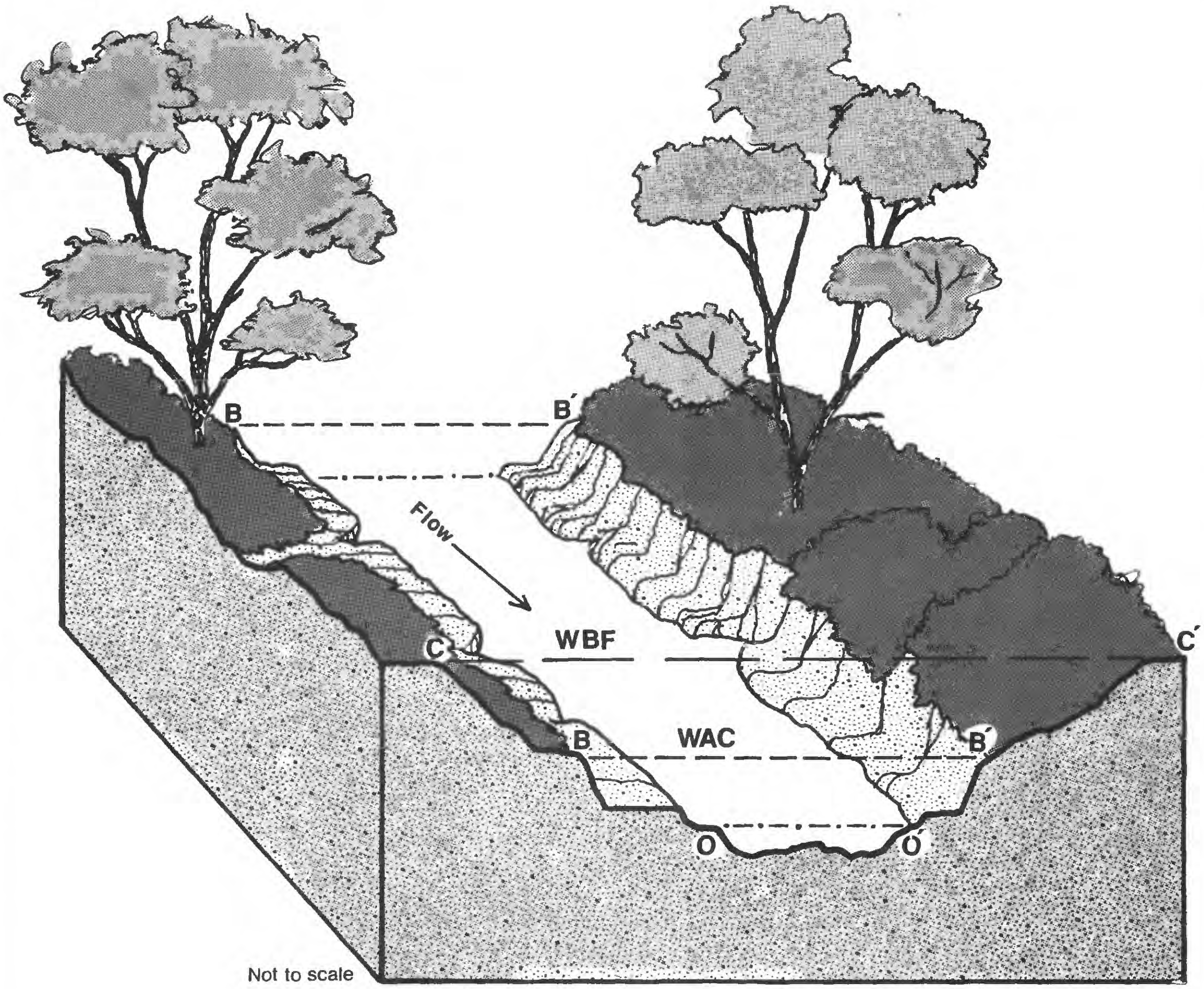
Ten channel characteristics were measured or computed for use in multiple-regression analyses to estimate flood peaks. Four were measured channel-geometry characteristics and six were grain-size characteristics from analysis of streambed and streambank samples. The grain-size characteristics were not determined at bedrock (firm bottom) channel sites. Channel and grain-size data used in multiple-regression analysis were:

Channel-geometry characteristics

- WAC -- width of active channel, in feet (fig. 2).
- DAC -- average depth of active channel, in feet.
- WBF -- width of bankfull channel, in feet (fig. 2).
- DBF -- average depth of bankfull channel, in feet.

Grain-size characteristics

- BEDSC -- percentage of silt and clay in streambed.
- BANKSC -- percentage of silt and clay in streambanks.
- MBED -- median grain size of the composite streambed sample.
- COBANK -- larger of the two individual streambank median grain sizes (coarse bank).
- FIBANK -- smaller of the two individual streambank median grain sizes (fine bank).
- MCBANK -- median grain size of the composite streambank sample.



EXPLANATION

C-C′ = ——— ——— Bankfull reference line

B-B′ = — — — — — Active-channel reference line

O-O′ = ·— ·—·—·— Low-flow water level

WBF = Bankfull width

WAC = Active-channel width

From Webber and Roberts (1981)

Figure 2.—Block diagram of a typical stream channel.

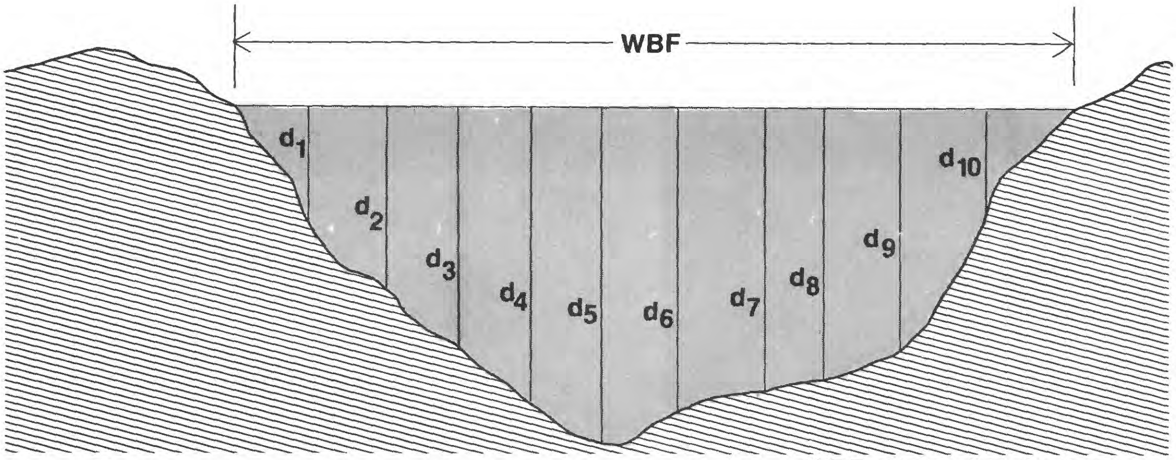
As defined by Osterkamp and Hedman (1977, p. 256):

> The active channel is a short-term geomorphic feature subject to change by prevailing discharges. The upper limit is defined by a break in the relatively steep bank slope of the active channel to a more gently sloping surface beyond the channel edge. The break in slope normally coincides with the lower limit of permanent vegetation so that the two features, individually or in combination, define the active channel reference level. The section beneath the reference level is that portion of the stream entrenchment in which the channel is actively, if not totally, sculptured by the normal process of water and sediment discharge.

The boundaries that define the bankfull channel are the abrupt breaks in slope that are farther up the banks than the active-channel boundaries and that coincide with the flood plain. The depth of the active channel (DAC) and the depth of the bankfull channel (DBF) are the average depths of 10 equally spaced sections across the channel at the active-channel width and bankfull channel width lines, respectively. The technique for determining DBF is illustrated in figure 3. The channel-data method to determine flood peaks requires that the cross section of the stream in question be located in a straight reach. Ideally, width should be uniform throughout the reach for a distance of five to seven times the active-channel width. Reaches of bedrock control, altered channel, split channel, or apparent channel instability should be avoided as sites for measurement. Photographs of channels at typical alluvial and bedrock sites are shown in figure 4.

Streambed material was composited from sediment samples taken at points across the stream channels. Sediment samples were obtained from the left bank and from the right bank. Each bank sample was a composite of material taken from several points between the upper limit of the active channel and the top of the bank.

Percentages of silt and clay and median grain size were computed from dry-sieve sediment analysis of streambed and streambank materials. The bank sample (left or right) that had the larger median grain size was defined as the coarse-bank sample (COBANK). The bank sample with the smaller median grain size was defined as the fine-bank sample (FIBANK). The percentage of silt and clay in the streambanks (BANKSC) and median grain size of the composite streambank samples (MCBANK) were determined from analysis of composited material from both banks.



$$DBF = \frac{\sum_{i=1}^{10} d_i}{10}$$

WBF Width of bankfull channel

d_4 Measured depth

DBF Calculated depth of bankfull channel

Figure 3.--Determination of average depth of bankfull channel.

A. Bedrock channel, Sunfish Creek near Woodsfield.

B. Active-channel with, Emerson Creek near Green Springs

Figure 4.--Channel geometry of typical alluvial and bedrock sites in Ohio.

C. Active-channel width, McMahon Creek near Glencoe

D. Bedrock channel, Timber Run near Zanesville

Figure 4.--Channel geometry of typical alluvial and bedrock sites in Ohio --Continued.

E. Active-channel width and depth of bankfull channel, Stoney Creek near DeGraff

Figure 4.--Channel geometry of typical alluvial and bedrock sites in Ohio--Continued.

REGRESSION ANALYSES

Alluvial Channels

All six of the channel characteristics used by Webber and Roberts (WAC, DAC, WBF, DBF, BEDSC, and BANKSC) and the four median grain-size characteristics (MBED, COBANK, FIBANK, and MCBANK) were used as independent variables in a series of multiple regression analyses. Some of the values were missing for the channel characteristics; therefore, only 142 of the original 170 sites were used in the analysis discussed in this report. Webber and Roberts (1981) used 162 of the 170 sites in their regression analysis. The variables were more nearly lognormal than normal, and therefore were transformed to their base 10 logarithmic values. In order to avoid negative logarithms, the number 1 was added to all median grain-size values (MBED, COBANK, FIBANK, and MCBANK) and to depth of active channel (DAC) before transformation.

The dependent variables for the analyses were peak discharges for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrance-interval floods. Regression analyses were done to determine if any of the median grain-size characteristics were statistically significant and should be used as independent variables in the equation to estimate peak discharge on streams in Ohio. Osterkamp (1977) found that certain grain-size characteristics of bed and bank materials were statistically significant in an analysis of channel data for streams in Kansas and Missouri.

One of the median grain-size variables (COBANK+1) was significant at the 5-percent level for all recurrance intervals; however, improvements in the standard errors of estimate by including COBANK+1 are so small (less than 5 percent) that COBANK+1 was not included as an independent variable in the estimating equations.

Table 1 lists all hydrologic data collected and used in the regression analysis of Webber and Roberts (1981). The equations for estimating the 2- and 100-year floods in table 2 show the small change (less than 5 percent) in the standard errors of estimate when one or more grain-size variables are added to the equations. For example, the equation for estimating Q_{100} using only WAC has an average standard error of 53 percent. If the median grain size-variables COBANK+1 and MBED+1 are included in the equations, the standard error is 52 percent. Thus, by adding COBANK+1, and MBED+1, the standard error is lowered only by 1 percent.

Residuals, the differences between the observed and the estimated values, were computed for all equations and were used to check for any errors in the original data set. Residuals were also used to check for the existence of geographic bias. None was found.

Table 1--Hydrologic data for selected

Station number	Station name	Geographic area	Drainage area (A) (mi^2)	Type of gage[2]	Length of record (yr)	WAC (ft)
	OHIO RIVER BASIN					
03086500	Mahoning River at Alliance	1	89.2	R	34	45
03087000	Beech Creek near Bolton	1	17.4	R	11	16
03088000	Deer Creek at Limaville	1	31.9	R	15	32
03089500	Mill Creek near Berlin Center	1	19.1	R-C	34	28
03092090	West Branch Mahoning River near Ravenna	1	21.8	R	10	24
03093000	Eagle Creek at Phalanx Station	1	97.6	R	46	37
03102900	Clear Creek at Dilworth	1	1.13	C	29	5.0
03102950	Pymatuning Creek at Kinsman	1	96.7	R	10	27
03109500	Little Beaver Creek near East Liverpool[1]	1	496	R	60	126
03110000	Yellow Creek near Hammondsville	5	147	R	35	62
03111500	Short Creek near Dillonvale	5	123	R	34	43
03114000	Captina Creek at Armstrongs Mills	2	134	R	26	85
03115400	Little Muskingum River at Bloomfield	2	210	R	17	68
03115600	Barnes Run near Summerfield	2	3.46	C	29	9.0
03116000	Tuscarawas River at Clinton	5	174	R	49	43
03116100	Little Chippewa Creek near Smithville	5	16.4	C	26	16
03116200	Chippewa Creek at Easton	5	146	R	17	60
03117000	Tuscarawas River at Massillon	5	526	R	37	98
03117500	Sandy Creek at Waynesburg	5	253	R	37	75
03118000	Middle Branch Nimishillen Creek at Canton	5	43.1	R	34	32
03118500	Nimishillen Creek at North Industry[1]	5	175	R	54	58
03119000	Sandy Creek at Sandyville	5	481	R	24	82
03119700	Conotton Creek at Jewett	5	14.3	C	29	16
03122500	Tuscarawas River below Dover Dam near Dover	5	1,405	R	15	277
03123400	Dundee Creek at Dundee	5	0.71	C	10	4.8
03125000	Home Creek near New Philadelphia	5	1.64	R	39	5.5
03129000	Tuscarawas River at Newcomerstown	2	2,443	R-C	17	242
03129014	White Eyes Creek tributary near Coshocton (ARS station 196)	2	0.473	R	34	2.8
03129016	White Eyes Creek tributary near Coshocton (ARS station 183)	2	0.116	R	25	2.0
03129300	Whetstone Creek tributary near Olivesburg	2	0.240	C	26	2.5
03130500	Touby Run at Mansfield	2	5.44	R	29	15
03132000	Clear Fork at Butler	2	136	R	30	54
03134000	Jerome Fork near Jeromeville	2	120	C	30	33
03136000	Mohican River at Greer	2	948	R	17	182
03136500	Kokosing River at Mount Vernon	2	202	R	23	78

See footnotes at end of table.

Ohio streams with alluvial channels

Channel-geometry and grain-size variables (See p. 4 for definitions)								
DAC (ft)	WBF (ft)	DBF (ft)	BEDSC (%)	BANKSC (%)	MBED (mm)	COBANK (mm)	FIBANK (mm)	MCBANK (mm)
--	--	--	--	--	--	--	--	--
1.0	28	2.3	1	34	8.189	0.111	0.111	0.111
1.0	51	3.1	1	14	10.097	0.165	0.165	0.165
1.4	38	2.7	1	37	3.502	0.105	0.105	0.105
1.6	41	4.3	1	12	10.793	0.189	0.189	0.189
1.8	58	5.6	1	12	7.391	0.156	0.156	0.156
0.88	13	1.5	1	8	12.388	4.992	0.261	0.731
1.9	37	3.6	2	29	3.614	0.143	0.143	0.143
--	--	--	--	--	6.128	0.187	0.187	0.187
2.3	108	5.6	1	18	--	--	--	--
2.3	53	3.6	1	17	11.65	0.403	0.403	0.403
2.2	110	7.9	1	16	8.014	0.325	0.165	0.241
4.0	105	12.0	3	35	0.146	0.115	0.115	0.115
1.2	21	1.9	4	20	6.772	0.208	0.208	0.208
3.3	56	6.3	1	36	0.782	0.106	0.106	0.106
1.5	35	3.0	1	31	7.312	0.136	0.136	0.136
1.7	84	5.5	2	32	0.185	0.103	0.103	0.103
3.5	115	7.1	1	28	4.376	0.254	0.254	0.254
2.6	84	4.1	2	15	2.579	0.209	0.209	0.209
1.9	62	2.0	2	57	--	--	--	--
--	--	--	--	--	16.158	1.016	0.097	0.193
1.9	101	5.6	1	37	4.058	0.100	0.100	0.100
1.4	32	2.4	3	23	1.335	0.159	0.159	0.159
4.0	302	7.1	10	36	2.303	0.094	0.094	0.094
0.92	12	1.4	2	16	4.393	0.671	0.671	0.671
1.4	12.5	1.5	15	41	0.358	0.099	0.099	0.099
3.8	260	8.8	2	35	14.904	0.025	0.025	0.025
0.37	15	1.3	1	35	9.862	0.096	0.096	0.096
0.25	9.5	0.49	4	13	5.574	0.989	0.989	0.989
0.46	8.5	1.1	38	32	0.101	0.133	0.133	0.133
1.3	23	2.6	1	25	2.510	0.137	0.137	0.137
1.4	77	3.4	1	24	3.000	0.147	0.147	0.147
1.4	69	6.3	7	29	0.458	0.103	0.103	0.103
4.3	242	6.7	7	39	10.696	0.086	0.086	0.086
2.1	139	5.5	1	14	4.275	0.186	0.186	0.186

Table 1--Hydrologic data for selected Ohio

Station number	Station name	Geographic area	Drainage area (A) (mi^2)	Type of gage[2]	Length of record (yr)	WAC (ft)
03137000	Kokosing River at Millwood	2	455	R	54	102
03138500	Walhonding River below Mohawk Dam near Nellie	2	1,505	R	17	261
03138900	Jennings Ditch tributary near Wooster	2	0.900	C	11	4.0
03139000	Killbuck Creek at Killbuck	2	462	R-C	45	95
03139940	Little Mill Creek near Coshocton (ARS station 92)	2	1.44	R	35	4.3
03139960	Little Mill Creek near Coshocton (ARS station 94)	2	2.38	R	35	5.5
03139990	Little Mill Creek near Coshocton (ARS station 97)	2	7.16	R	36	11
03140000	Mill Creek near Coshocton[1]	2	27.2	R	39	25
03144000	Wakatomika Creek near Frazeysburg	2	140	R	39	68
03144500	Muskingum River at Dresden	2	5,993	R	17	407
03144800	Etna Creek at Etna	2	1.10	C	10	2.5
03145500	Raccoon Creek at Granville	2	82.7	C	10	48
03145600	Otter Fork near Centerburg	2	3.17	C	29	4.0
03146000	North Fork Licking River at Utica	2	116	R-C	15	68
03146500	Licking River near Newark	2	537	R	36	169
03147900	Timber Run near Zanesville	2	10.1	R-C	29	18
03148300	Moxahala Creek at Roseville	2	80.6	C	13	65
03149500	Salt Creek near Chandlersville	2	75.7	R	13	35
03150000	Muskingum River at McConnelsville	2	7,422	R	16	495
03150600	Tupper Creek at DeVola	2	0.99	C	10	4.5
03157000	Clear Creek near Rockbridge	2	89.0	R	36	55
03157500	Hocking River at Enterprise	2	459	R	45	91
03159500	Hocking River at Athens[1]	2	943	R	61	131
03159540	Shade River near Chester	2	156	R	10	58
03202000	Raccoon Creek at Adamsville	2	585	R	58	91
03217500	Scioto River at LaRue	3	255	R	24	78
03218000	Little Scioto River above Marion	3	72.4	R	37	37
03219500	Scioto River near Prospect	3	567	R	62	134
03220000	Mill Creek near Bellepoint	3	178	R-C	33	82
03221000	Scioto River below O'Shaughnessy Dam near Dublin	3	980	R	52	187
03223000	Olentangy River at Claridon	3	157	R	29	77
03224000	Shaw Creek at Shawtown	3	25.4	R	10	25
03226200	Delaware Run near Delaware	3	5.84	C	29	9.0
03226850	Linworth Run near Linworth	3	0.40	C	10	4.5
03228000	Scioto Big Run at Briggsdale	3	11.0	R-C	29	18.5
03229500	Big Walnut Creek at Rees	3	544	R	32	123
03230500	Big Darby Creek at Darbyville	3	534	R	53	128
03230600	Hominy Creek at Circleville	3	5.66	C	29	14
03230800	Deer Creek at Mt. Sterling	3	228	R	13	85
03231000	Deer Creek at Williamsport	3	333	R-C	36	95

See footnotes at end of table.

Channel-geometry and grain-size variables (See p. 4 for definitions)

DAC (ft)	WBF (ft)	DBF (ft)	BEDSC (%)	BANKSC (%)	MBED (mm)	COBANK (mm)	FIBANK (mm)	MCBANK (mm)
2.1	140	5.9	1	28	8.443	0.127	0.127	0.127
5.4	274	12.4	4	7	2.175	0.367	0.367	0.367
0.72	14	0.88	8	23	8.826	0.188	0.188	0.188
3.1	108	6.3	5	32	0.081	0.085	0.085	0.085
0.71	14.5	1.3	1	22	2.811	0.199	0.199	0.199
1.1	20	1.6	1	31	9.574	0.152	0.152	0.152
1.1	32	1.8	3	27	18.572	0.140	0.140	0.140
--	--	--	--	--	--	--	--	--
1.8	85	7.0	4	43	0.373	0.076	0.076	0.076
5.2	428	13.0	8	37	18.572	0.089	0.089	0.089
0.41	12	0.46	4	37	2.768	0.128	0.128	0.128
2.8	61	6.3	1	21	3.47	0.353	0.888	0.120
0.42	34	1.6	4	41	5.61	0.090	0.090	0.090
1.6	127	5.2	5	40	--	--	--	--
5.6	184	11.1	6	49	8.288	0.064	0.064	0.064
1.7	48	3.7	1	31	3.654	0.132	0.132	0.132
2.5	80	6.1	1	36	0.456	0.090	0.090	0.090
2.4	59	8.7	1	20	0.239	0.896	0.104	0.199
12.6	535	17.0	7	43	--	0.078	0.078	0.078
0.77	13	1.8	6	22	1.10	0.176	0.176	0.176
2.3	99	7.8	1	31	5.472	0.156	0.063	0.120
4.4	109	10.8	1	23	9.411	0.114	0.144	0.144
--	--	--	--	--	--	--	--	--
2.2	74	8.1	1	49	3.76	0.063	0.063	0.063
5.3	119	11.7	8	22	0.319	0.161	0.111	0.148
4.4	100	9.3	5	29	4.726	0.253	0.253	0.253
0.88	105	3.8	1	30	19.144	0.138	0.138	0.138
4.9	156	7.6	3	31	0.126	0.142	0.142	0.142
2.6	157	4.8	1	26	14.449	0.613	0.117	0.248
3.9	294	8.8	1	15	10.151	4.503	0.145	0.362
2.5	94	7.4	2	30	1.211	0.166	0.166	0.166
2.5	35	3.5	1	31	18.604	0.142	0.142	0.142
0.92	20	1.6	5	34	0.922	0.153	0.153	0.153
0.64	9	1.1	1	12	6.373	0.364	0.364	0.364
0.9	45	4.3	1	15	5.77	0.273	0.133	0.203
4.8	146	10.2	5	26	0.325	0.247	0.062	0.166
4.3	146	11.4	2	35	6.76	0.110	0.110	0.110
1.4	40	3.9	1	15	4.017	0.162	0.162	0.162
2.1	130	5.8	1	30	7.79	0.153	0.099	0.132
2.7	115	5.2	21	4	0.169	0.851	0.851	0.851

Table 1--Hydrologic data for selected Ohio

Station number	Station name	Geographic area	Drainage area (A) (mi^2)	Type of gage[2]	Length of record (yr)	WAC (ft)
03231500	Scioto River at Chillicothe	3	3,849	R	59	302
03231600	East Fork Paint Creek near Sedalia	3	3.82	C	29	7.5
03232000	Paint Creek near Greenfield	3	249	R-C	44	73
03232500	Rocky Fork near Barretts Mills	3	140	R	12	86
03234000	Paint Creek near Bourneville	3	807	R	49	128
03234100	Indian Creek at Massieville	3	9.60	C	29	30
03234500	Scioto River at Higby[1]	3	5,131	R	45	410
03235000	Salt Creek at Tarlton[1]	3	11.5	R-C	29	22
03235200	Little Blackjack Branch near South Bloomingville	3	0.89	C	10	6.0
03235500	Tar Hollow Creek at Tar Hollow State Park	3	1.35	R	29	9.0
03235995	Salt Creek above dam site near Londonderry	3	268	C	13	92
03236100	South Branch Little Salt Creek at Jackson	3	3.76	C	29	11.5
03237280	Upper Twin Creek at McGaw	3	12.2	R	13	39
03237300	West Branch Turkey Run near Winchester	3	0.89	C	20	4.0
03237500	Ohio Brush Creek near West Union	3	387	R	44	139
03238400	Harwood Creek near Fayetteville	3	0.88	C	10	3,0
03238500	Whiteoak Creek near Georgetown	3	222	R	48	90
03239000	Little Miami River near Selma	3	48.9	R-C	23	35
03239500	North Fork Little Miami River near Pitchin	3	28.9	R-C	23	23
03240000	Little Miami River near Oldtown	3	129	R	23	65
03240500	North Fork Massies Creek at Cedarville	3	28.9	R	14	20.5
03241000	South Fork Massies Creek near Cedarville	3	17.1	R	14	15.5
03241500	Massies Creek at Wilberforce	3	63.2	R	23	37
03241600	Shawnee Creek at Xenia	3	4.21	C	28	10
03242050	Little Miami River near Spring Valley	3	366	R	33	99
03242100	Wayne Creek at Waynesville	3	1.01	C	10	11
03242500	Little Miami River near Fort Ancient	3	677	R	17	145
03244000	Todd Fork near Roachester	3	219	R	22	83
03245500	Little Miami River at Milford	3	1,203	R	52	220
03247100	Patterson Run near Owensville	3	3.34	R-C	29	20.5
03247500	East Fork Little Miami River at Perintown	3	476	R	54	129
03255500	Mill Creek at Reading	3	73.0	R	37	59
03260700	Bokengehalas Creek near DeGraff	3	36.3	R	18	19
03260800	Stony Creek near DeGraff	3	59.1	R	18	31
03261500	Great Miami River at Sidney	3	541	R	63	95
03262750	Millers Ditch near Tipp City	3	0.81	C	10	4.2
03263100	Poplar Creek near Vandalia	3	3.11	R-C	29	14
03263700	Bridge Creek near Greenville	3	4.83	C	29	8.2
03264000	Greenville Creek near Bradford	3	193	R	45	60
03265100	Hog Run tributary at Laura	3	0.460	R-C	26	2.2

See footnotes at end of table.

streams with alluvial channels--Continued

Channel-geometry and grain-size variables (See p. 4 for definitions)

DAC (ft)	WBF (ft)	DBF (ft)	BEDSC (%)	BANKSC (%)	MBED (mm)	COBANK (mm)	FIBANK (mm)	MCBANK (mm)
9.2	336	17.7	1	39	0.086	0.097	0.097	0.097
0.78	29	3.9	2	38	3.18	0.107	0.107	0.107
2.8	96	5.7	2	56	--	--	--	
2.9	107	8.5	1	30	3.053	0.143	0.073	0.111
5.1	210	14.5	1	34	1.811	0.094	0.094	0.094
1.9	48	3.4	1	18	--	--	--	--
--	--	--	--	--	8.151	0.069	0.069	0.069
--	--	--	--	--	4.672	0.205	0.031	0. 39
0.45	16	1.5	2	40	5.378	0.079	0.079	0.079
0.75	24	1.7	2	50	--	--	--	--
2.9	128	9.1	1	35	4.425	0.082	0.082	0.082
1.0	23	2.8	2	30	--	--	--	
1.3	58	6.5	1	12	14.030	4.457	0.228	1.224
0.54	22	1.2	1	27	0.157	0.157	0.157	0.157
5.1	160	11.2	1	41	10.448	0.088	0.088	0.088
0.92	25	1.03	5	33	5.549	0.143	0.143	0.143
2.7	113	9.1	1	30	--	--	--	--
2.4	74	2.8	2	54	5.398	0.053	0.053	0.053
1.1	47	2.9	1	34	6.085	0.128	0.128	0.128
2.4	80	7.3	1	14	5.172	0.315	0.315	0.315
1.3	49	2.3	1	41	8.190	0.102	0.102	0.102
1.6	52	2.6	2	40	12.251	0.110	0.110	0.110
1.7	56	5.0	1	12	5.789	0.209	0.209	0.209
1.3	34	3.2	1	11	2.256	0.351	0.172	0.303
2.4	111	7.3	1	45	9.921	0.076	0.076	0.076
0.82	35	3.1	1	25	4.268	0.479	0.093	0.202
5.4	179	12.0	3	43	0.084	0.085	0.085	0.085
2.2	140	6.6	1	23	1.825	0.268	0.098	0.190
6.6	294	11.6	3	16	0.941	0.176	0.176	0.176
1.3	35	2.8	1	30	--	--	--	--
2.6	156	14.0	1	39	2.148	0.091	0.091	0.091
2.4	90	9.4	1	30	--	--	--	--
1.6	72	3.1	1	15	3.423	0.364	0.364	0.364
2.2	40	5.6	3	38	0.624	0.093	0.093	0.093
2.2	133	6.7	1	38	0.682	0.086	0.086	0.086
1.04	26	3.3	1	28	1.474	0.219	0.219	0.219
1.3	25	2.7	1	20	4.139	0.165	0.123	0.150
1.7	28	2.9	27	31	0.200	0.151	0.151	0.150
2.2	140	6.6	1	23	12.20	0.193	0.193	0.193
0.45	15	1.4	16	34	0.443	0.167	0.167	0.167

Table 1--Hydrologic data for selected Ohio

Station number	Station name	Geographic area	Drainage area (A) (mi²)	Type of gage[2]	Length of record (yr)	WAC (ft)
03267000	Mad River near Urbana	3	162	R	42	51
03267900	Mad River, St. Paris Pike, near Eagle City	3	310	R	10	81
03268000	Buck Creek at New Moorefield	3	67.3	R	17	46
03268300	Beaver Creek at Brighton	3	3.33	C	17	8.5
03268500	Beaver Creek near Springfield	3	39.2	R-C	20	29
03269000	Buck Creek at Springfield	3	139	R-C	56	63
03269500	Mad River near Springfield	3	490	R	65	106
03270800	Wolf Creek at Trotwood	3	22.7	R	14	29
03271000	Wolf Creek at Dayton	3	69.5	R-C	12	40
03271800	Twin Creek near Ingomar	3	197	R	14	84
03272800	Sevenmile Creek at Collinsville	3	120	R	16	87
03272900	Collins Creek at Collinsville	3	0.94	C	10	5.0
03273500	Fourmile Creek near Hamilton	3	311	R	23	150
03274100	Blake Run near Reily[1]	3	0.29	R-C	33	3.0
		ST. LAWRENCE RIVER BASIN				
04177400	Eagle Creek tributary near Montpelier	4	1.84	C	26	4.5
04178000	St. Joseph River near Newville, Indiana	4	160	R	29	103
04183500	Maumee River at Antwerp	4	2,128	R	64	230
04184500	Bean Creek at Powers	4	206	R	35	48
04185000	Tiffin River at Stryker	4	410	R	44	100
04186500	Auglaize River near Fort Jennings	4	332	R	50	88
04186800	King Run near Harrod	4	0.53	C	10	4.0
04187500	Ottawa River at Allentown	4	160	R	46	58
04189000	Blanchard River near Findlay	4	346	R	49	71
04189100	Tiderishi Creek near Jenera	4	4.65	C	29	6.5
04189500	Blanchard River at Glandorf	4	644	C	13	112
04190500	Roller Creek at Ohio City	4	5.14	R-C	29	5.0
04191500	Auglaize River near Defiance	4	2,318	R	61	360
04192500	Maumee River near Defiance	4	5,545	R	49	490
04195500	Portage River at Woodville	4	428	R	44	83
04196000	Sandusky River near Bucyrus	4	88.8	R	36	50
04196500	Sandusky River near Upper Sandusky	4	298	R	53	99
04196700	St. James Run near Upper Sandusky	4	5.29	C	29	7.0
04196800	Tymochtee Creek at Crawford	4	229	R-C	15	61
04197000	Sandusky River near Mexico[1]	4	774	R	53	125
04197100	Honey Creek at Melmore	4	149	R-C	15	43

See footnotes at end of table.

streams with alluvial channels--Continued

Channel-geometry and grain-size variables (See p. 4 for definitions)

DAC (ft)	WBF (ft)	DBF (ft)	BEDSC (%)	BANKSC (%)	MBED (mm)	COBANK (mm)	FIBANK (mm)	MCBANK (mm)
1.4	99	7.1	1	48	5.522	0.074	0.074	0.074
3.0	110	8.1	1	30	6.606	0.112	0.112	0.112
2.4	75	7.0	4	30	1.499	0.244	0.244	0.244
1.3	30	2.6	1	41	10.188	0.191	0.191	0.191
1.2	98	6.7	1	22	1.529	0.334	0.319	0.330
1.9	160	6.3	1	30	6.900	0.073	0.073	0.073
3.9	125	8.9	1	30	4.273	0.282	0.018	0.182
1.7	56	3.5	1	5	2.767	0.416	0.229	0.302
1.5	84	4.2	1	5	3.700	0.239	0.129	0.181
2.7	191	5.9	1	19	10.968	0.152	0.152	0.152
1.6	131	8.4	1	18	8.142	0.182	0.182	0.182
0.82	42	1.9	7	36	2.281	0.119	0.119	0.119
2.2	195	9.0	1	50	12.714	0.063	0.063	0.063
--	--	--	--	--	0.667	0.053	0.053	0.053
1.03	22	2.9	19	39	0.287	0.096	0.096	0.096
3.2	148	7.6	2	20	0.358	1.234	0.131	0.283
3.8	274	9.8	1	32	6.814	0.118	0.118	0.118
1.9	70	7.9	1	34	2.084	0.117	0.085	0.102
3.7	149	10.0	1	38	0.094	0.097	0.097	0.097
--	--	--	--	--	10.923	0.084	0.084	0.084
0.91	19	1.4	1	33	--	0.148	0.148	0.148
1.4	103	4.6	1	38	10.590	0.107	0.107	0.107
1.6	160	7.0	1	38	3.982	0.091	0.091	0.091
0.96	28	2.8	10	36	0.515	0.132	0.132	0.132
5.7	147	12.9	1	22	0.095	0.740	0.131	0.435
0.55	28	4.2	3	37	2.498	0.112	0.112	0.112
5.2	415	16.0	1	16	--	--	--	--
6.9	530	13.7	1	30	--	--	--	--
1.2	150	6.4	1	36	18.264	0.128	0.128	0.128
1.8	66	4.5	1	37	3.271	0.104	0.104	0.104
2.1	148	6.0	1	46	17.55	0.069	0.069	0.069
1.03	18	2.9	3	34	1.422	0.146	0.146	0.146
3.5	96	5.8	15	35	14.433	0.273	0.076	0.131
--	--	--	--	--	3.775	0.112	0.112	0.112
1.5	137	4.9	1	31	5.716	0.169	0.169	0.169

Table 1--Hydrologic data for selected Ohio

Station number	Station name	Geographic area	Drainage area (A) (mi^2)	Type of gage[2]	Length of record (yr)	WAC (ft)
04197300	Wolf Creek at Bettsville	4	66.2	C	15	35
04197400	East Branch Wolf Creek at Fort Seneca	4	70.1	C	15	34
04197500	Havens Creek at Havens	4	4.28	R-C	29	7.0
04198000	Sandusky River near Fremont	4	1,251	R	50	240
04198100	Norwalk Creek at Norwalk	1	4.92	C	29	7.5
04199000	Huron River at Milan	1	371	R	26	110
04199500	Vermilion River at Vermilion	1	262	R	26	107
04199800	Neff Run near Litchfield	1	0.76	C	10	4.0
04200100	Plum Creek at Oberlin	1	4.83	C	29	6.5
04200500	Black River at Elyria	1	396	R	31	92
04202000	Cuyahoga River at Hiram Rapids	1	151	R	24	69
04206000	Cuyahoga River at Old Portage	1	404	R	52	102
04207200	Tinkers Creek at Bedford	1	83.9	R	13	35
04208000	Cuyahoga River at Independence	1	707	R	47	90
04210000	Phelps Creek near Windsor	1	25.6	R	18	21
04210090	Montville Ditch at Montville	1	0.29	C	10	3.0
04210100	Hoskins Creek at Hartsgrove	1	5.11	C	29	7.0
04211500	Mill Creek near Jefferson	1	82.0	R	33	41
04212000	Grand River near Madison	1	581	R-C	51	88
04213000	Conneaut Creek at Conneaut	1	175	R	40	59

[1] Check station, not used in regression analysis.
[2] Type of gage: R = recording, C = crest-stage.

streams with alluvial channels--Continued

Channel-geometry and grain-size variables (See p. 4 for definitions)

DAC (ft)	WBF (ft)	DBF (ft)	BEDSC (%)	BANKSC (%)	MBED (mm)	COBANK (mm)	FIBANK (mm)	MCBANK (mm)
1.0	51	2.3	1	20	--	0.612	0.097	0.337
2.7	83	5.4	45	43	0.071	0.089	0.089	0.089
0.67	25	3.1	11	38	0.429	0.108	0.082	0.082
2.8	290	8.6	1	30	--	--	--	--
0.61	21	1.4	2	20	3.295	0.236	0.236	0.236
3.0	159	7.4	1	29	4.97	0.114	0.114	0.114
1.5	170	7.7	1	32	6.923	0.164	0.077	0.120
0.49	20	1.5	1	40	--	0.111	0.111	0.111
0.66	31	2.9	1	20	2.715	0.198	0.121	0.157
2.7	145	7.2	3	27	0.271	0.178	0.092	0.155
3.6	93	6.0	1	15	9.025	2.389	0.166	0.407
3.3	128	8.4	1	25	--	--	--	--
1.8	41	3.9	1	32	8.481	0.128	0.128	0.128
5.0	125	9.4	1	31	20.599	0.112	0.122	0.122
2.1	61	5.5	1	14	5.396	0.175	0.175	0.175
0.56	10	1	3	29	2.765	0.154	0.154	0.154
0.77	15	1.8	2	40	1.737	0.086	0.086	0.086
1.7	91	3.7	3	34	7.867	0.137	0.137	0.137
1.4	175	3.2	1	25	5.552	0.327	0.143	0.281
2.3	109	5.0	1	35	11.467	0.101	0.101	0.101

Table 2--Regression results for the 2-year and 100-year floods for alluvial channels if median grain-size variables are added to the analysis

Discharge	Independent variable[a]	Standard error of estimate (in percent) -	Average	+
Q_2	WAC,	33	41	50
Q_2	WAC, WBF	32	40	48
Q_2	WAC, WBF, (COBANK+1),	32	39	46
Q_2	WAC, WBF, BANKSC, (COBANK+1),	31	38	46
Q_{100}	WAC	40	53	66
Q_{100}	WAC, BANKSC, (MBED+1), (COBANK+1)	39	52	64
Q_{100}	WAC, WBF, BANKSC, (MBED+1)	39	51	63

[a] Median grain-size variables are underlined.

Results of the regression analysis indicate that only the width of active channel (WAC) should be used as an independent variable. This confirms the findings of Webber and Roberts (1981). Because the equations and corresponding standard errors determined as part of this study are similar to those from Webber and Roberts (1981), the following equations from their study are recommended for use in alluvial channels.

Equations	Standard error of estimate (in percent) -	Average	+
(1) $Q_2 = 16.5\ (WAC)^{1.31}$	34	42	51
(2) $Q_5 = 32.1\ (WAC)^{1.25}$	34	43	52
(3) $Q_{10} = 45.0\ (WAC)^{1.22}$	35	45	55
(4) $Q_{25} = 63.5\ (WAC)^{1.19}$	37	49	60
(5) $Q_{50} = 78.9\ (WAC)1.18$	39	52	64
(6) $Q_{100} = 95.7\ (WAC)^{1.16}$	41	55	69

Bedrock Channels

Bedrock or firm channels are quite common throughout Ohio; however, the equations developed by Webber and Roberts (1981) do not apply to bedrock channels. Additional data were collected and analyses were done in order to develop equations that could be used to estimate flood peaks on streams with bedrock or firm channels without using traditional basin characteristics. Channel-geometry characteristics (WAC, DAC, WBF, and DBF) were measured at 20 stream sites with bedrock or firm channels where flood peaks have been defined by means of streamflow records. (See figure 5 for location of sites and tables 3 and 4 for data.)

Multiple-regression analyses were done using the channel characteristics as independent variables and flood peaks with 2- through 100-year recurrence intervals as dependent variables. Independent and dependent variables were log transformed prior to analysis. In order to avoid negative logarithms, the depth of active channel (DAC) was multiplied by 10 prior to transformation. The analyses for bedrock channels showed two channel characteristics, WAC and DBF, to be statistically significant at the 5 percent level for all but the 2-year flood, in which only WAC was significant. Standard errors of estimate for the equations ranged from 33 to 40 percent when WAC and DBF independent variables are used for all equations, including the equation for the 2-year flood.

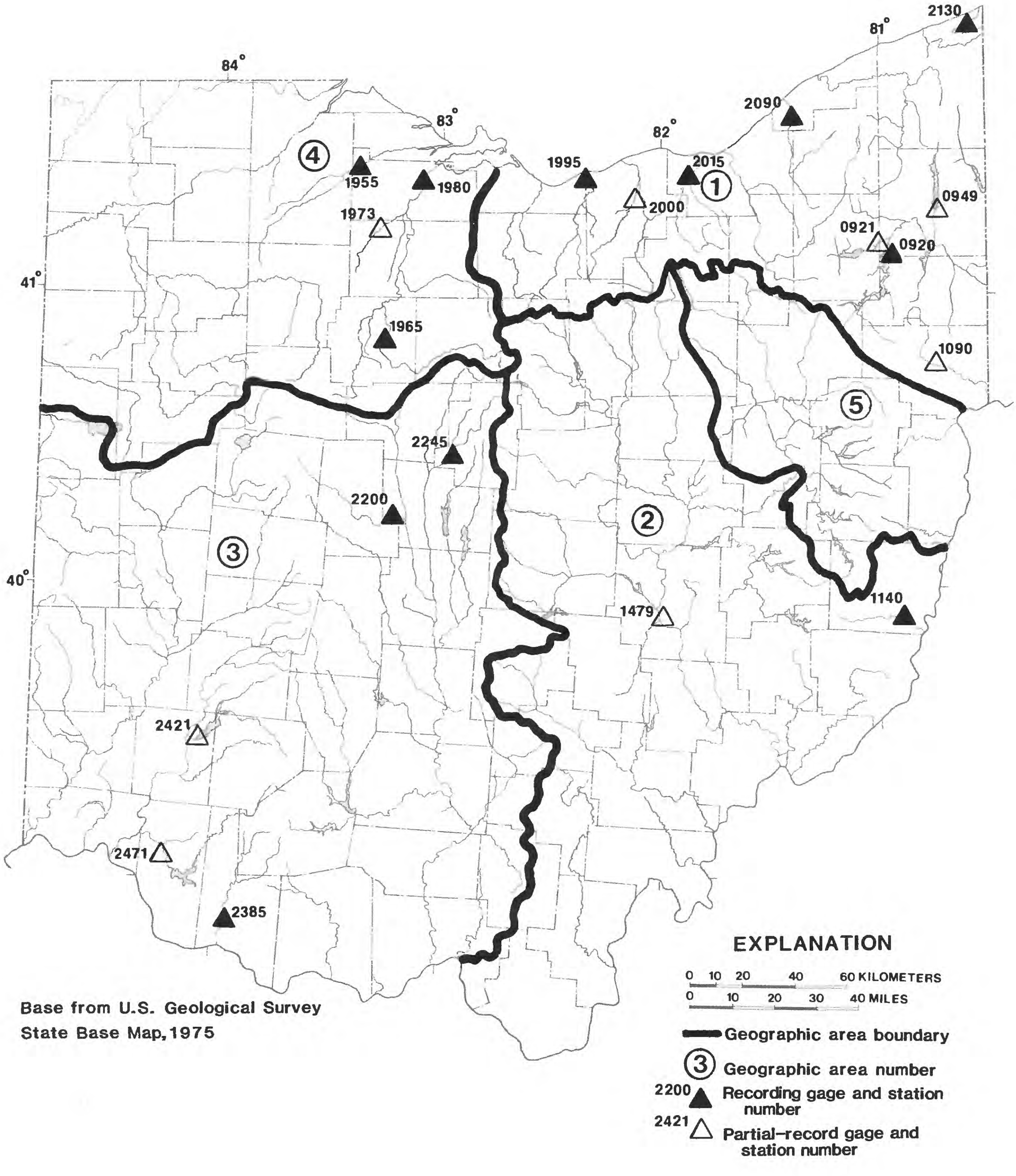


Figure 5.—Locations of gaging stations used in the bedrock-channel analysis.

Table 3--Hydrologic data for 20 selected Ohio streams with bedrock channels

Station number	Station name	Type of gage[a]	Length of record (years)	Drainage area (mi^2)	Geographic area	Active-channel width (WAC) (ft)	Average depth, active channel (DAC) (ft)	Bank-full channel width (WBF) (ft)	Average depth, bankfull channel (DBF) (ft)
03092000	Kale Creek near Pricetown	R	42	21.9	1	34.5	1.9	41.0	3.3
03092100	Hinkley Creek near Charlestown	C	36	10.6	1	25.7	0.6	56.0	2.5
03094900	Walnut Creek at Cortland	C	36	8.45	1	19.0	0.6	53.0	5.4
03109000	Lisbon Creek at Lisbon	C	36	6.19	1	24.5	1.4	30.0	2.6
03114000	Captina Creek at Armstrong Mills	R	28	151	2	90.0	3.0	107	7.2
03147900	Timber Run near Zanesville	R-C	30	10.1	2	24.0	1.3	37.0	3.6
03220000	Mill Creek near Bellpoint	C-R	35	178	3	64.0	2.4	120	6.0
03224500	Whetstone Creek near Ashley	R	28	61.7	3	58.0	2.2	70.0	6.5
03238500	Whiteoak Creek near Georgetown	R	50	222	3	110	2.8	141	8.5
03242100	Wayne Creek at Waynesville	C	12	1.01	3	14.0	1.2	22.0	2.9
03247100	Patterson Run near Owensville	R-C	31	3.34	3	26.0	1.8	53.0	4.4
04195500	Portage River at Woodville	R	46	428	4	105	2.0	150	6.4
04196500	Sandusky River near Upper Sandusky	R	55	298	4	108	1.2	139	7.1
04197300	Wolfe Creek at Bettsville	C	17	66.2	4	39.0	1.3	86.0	3.3
04197300	Sandusky Creek near Fremont	R	52	1,251	4	240	2.8	290	8.6
04198000	Vermilion River at Vermilion	R	28	262	1	107	1.5	170	7.7
04199500	East Branch Black River at Elyria	R	13	211	1	87.0	1.2	151	8.3
04201500	Rocky River near Berea	R	52	267	1	123	1.3	184	7.0
04209000	Chagrin River at Willoughby	R	52	246	1	115	1.5	161	9.2
04213000	Conneaut Creek at Conneaut	R	42	175	1	73.0	0.7	165	5.8

[a] R, recording; C, partial record

Table 4.--Flood-frequency data for 20 selected Ohio streams with bedrock channels

[Data are in cubic feet per second]

Station number	Station name	Recurrence interval and magnitude					
		2-year	5-year	10-year	25-year	50-year	100-year
03092000	Kale Creek near Pricetown	1,230	1,800	2,180	2,680	3,060	3,450
03092100	Hinkley Creek near Charlestown	339	513	646	834	989	1,160
03094900	Walnut Creek at Cortland	481	824	1,080	1,440	1,730	2,030
03109000	Lisbon Creek at Lisbon	382	617	793	1,030	1,230	1,430
03114000	Captina Creek at Armstrong Mills	[a]7,120	[a]9,820	[a]12,200	[a]15,500	[a]18,100	[a]20,800
03147900	Timber Run near Zanesville	770	1,280	1,650	2,160	2,560	2,980
03220000	Mill Creek near Bellpoint	4,420	6,550	8,060	10,100	11,600	13,200
03224500	Whetstone Creek near Ashley	[a]1,640	[a]2,700	[a]3,460	[a]4,500	[a]5,310	[a]6,190
03238500	Whiteoak Creek near Georgetown	9,920	13,700	16,200	19,300	21,600	23,800
03242100	Wayne Creek at Waynesville	305	524	683	896	1,060	1,230
03247100	Patterson Run near Owensville	575	749	853	974	1,060	1,140
04195500	Portage River at Woodville	6,170	8,510	9,220	11,500	12,700	13,700
04196500	Sandusky River near Upper Sandusky	4,700	6,670	7,900	9,380	10,400	11,400
04197300	Wolfe Creek at Bettsville	1,550	1,970	2,240	2,590	2,860	3,120
04197300	Sandusky Creek near Fremont	14,700	19,400	22,100	25,200	27,200	29,000
04199500	Vermilion River at Vermilion	5,600	9,280	12,700	18,400	24,000	30,900
04200000	East Branch Black River at at Elyria	4,720	7,670	9,940	13,100	15,800	18,600
04201500	Rocky River near Berea	7,820	10,900	13,000	15,700	17,600	19,600
04209000	Chagrin River at Willoughby	9,280	14,200	17,800	22,500	26,200	30,000
04213000	Conneaut Creek at Conneaut	6,010	8,840	10,700	13,100	14,900	16,700

[a]Discharges adjusted for intervening area (over 10 percent) between measuring site and gage.

The equations recommended for bedrock or firm channels are shown in table 5. For the sake of continuity, an equation including both WAC and DBF is provided for the 2-year flood. The 2-year and 100-year recurrence-interval equations (7 and 17, respectively) and supporting 20 data points are presented graphically in figures 6 and 7.

APPLICATION AND LIMITATIONS OF ALLUVIAL AND BEDROCK EQUATIONS

Example 1

The magnitude of a 50-year flood is needed at a site on an ungaged stream in the Scioto River basin. The channel at the site has an alluvial bottom and appears to be natural, that is, not altered by man. For alluvial channels, only the active-channel width (WAC) is needed for the estimating equation. The WAC in the vicinity of the site is 14 feet. Equation 5 (page 22) is used to estimate the 50-year flood at the site:

$$Q_{50} = 78.9\ (WAC)^{1.18}$$

$$Q_{50} = 78.9\ (14.0)^{1.18}$$

$$Q_{50} = 1{,}780\ ft^3/s$$

Example 2

The magnitude of a 25-year flood is needed at a site on an ungaged stream in the Black River basin. The channel in the vicinity of the site has a bedrock bottom and appears to be natural. The active and bankfull channels are well defined within the same channel reach. The estimating equation requires the active-channel width (WAC) and average depth of the bankfull channel (DBF).

The DBF is computed from ten equally spaced depth measurements of the bankfull channel, and, is found to be 4.2 feet. The WAC is 18.1 feet. Equation 14 (table 5) is used to estimate the 25-year flood at this site:

$$Q_{25} = 16.0\ WAC^{1.06}(DBF)^{0.922}$$

$$Q_{25} = 16.0\ (18.1)^{1.06}(4.2)^{0.922}$$

$$Q_{25} = 1{,}290\ ft^3/s$$

Table 5.--Equations for estimating flood frequency of streams with bedrock channels

Equation number	Equations	Standard error of estimate (in percent) -	Average	+
(7)	$Q_2 = 3.75(WAC)^{1.60}$	30	36	42
(8)	$Q2 = 4.30(WAC)^{1.32}(DBF)^{0.590}$	28	34	40
(9)	$Q_5 = 6.95(WAC)^{1.54}$	30	36	43
(10)	$Q_5 = 9.27(WAC)^{1.19}(DBF)^{0.751}$	28	33	38
(11)	$Q_{10} = 9.40(WAC)^{1.52}$	31	38	45
(12)	$Q_{10} = 11.4(WAC)^{1.13}(DBF)^{0.835}$	28	34	39
(13)	$Q_{25} = 12.9(WAC)^{1.50}$	33	41	49
(14)	$Q_{25} = 16.0(WAC)^{1.06}(DBF)^{0.922}$	29	35	41
(15)	$Q_{50} = 15.8(WAC)^{1.48}$	34	43	52
(16)	$Q_{50} = 19.8(WAC)^{1.02}(DBF)^{0.974}$	31	37	44
(17)	$Q_{100} = 19.0(WAC)^{1.47}$	36	46	56
(18)	$Q_{100} = 24.0(WAC)^{0.987}(DBF)^{1.02}$	32	40	47

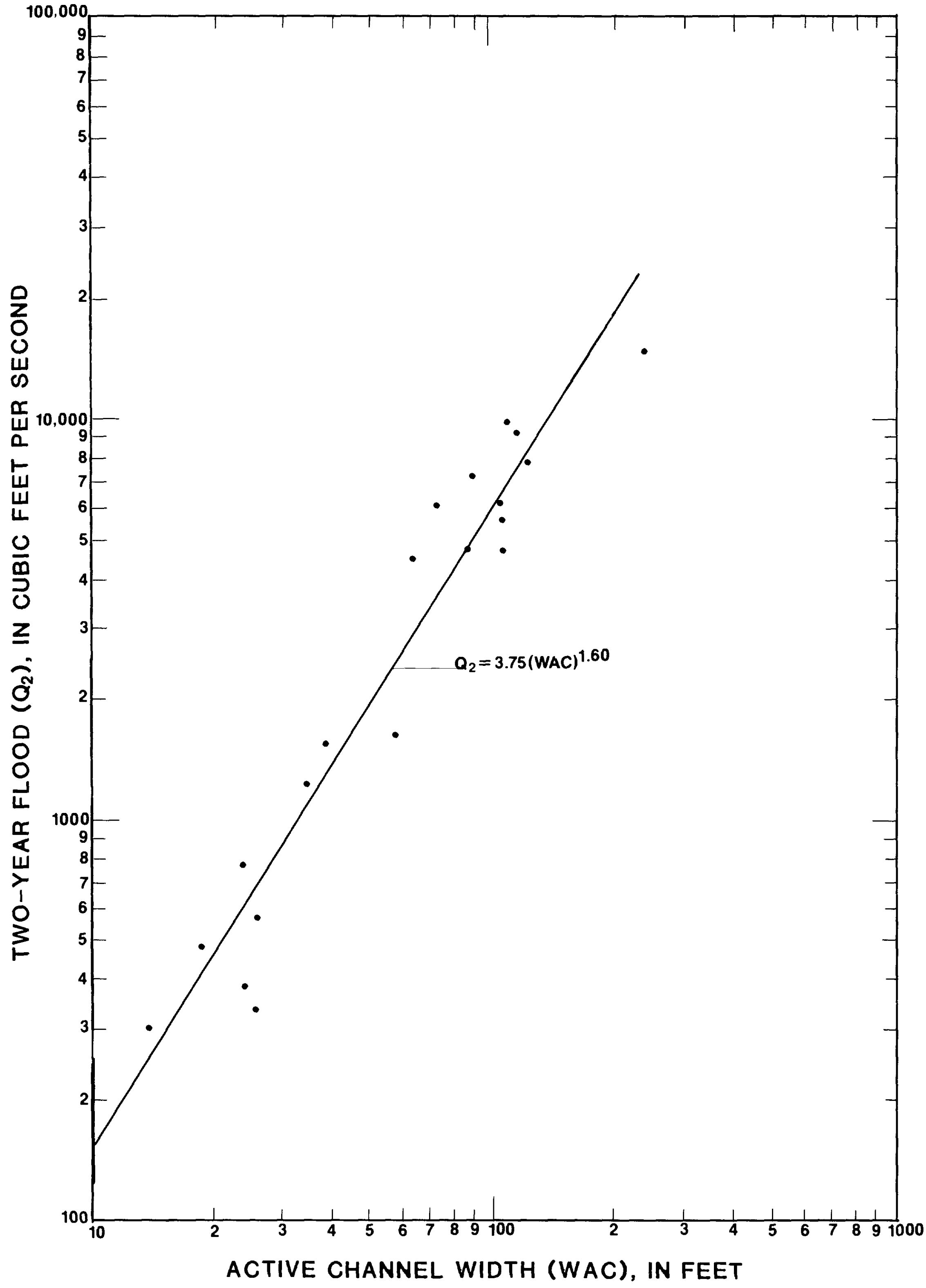


Figure 6.--Relation between active-channel width and flood-peak magnitude in bedrock channels, 2-year flood.

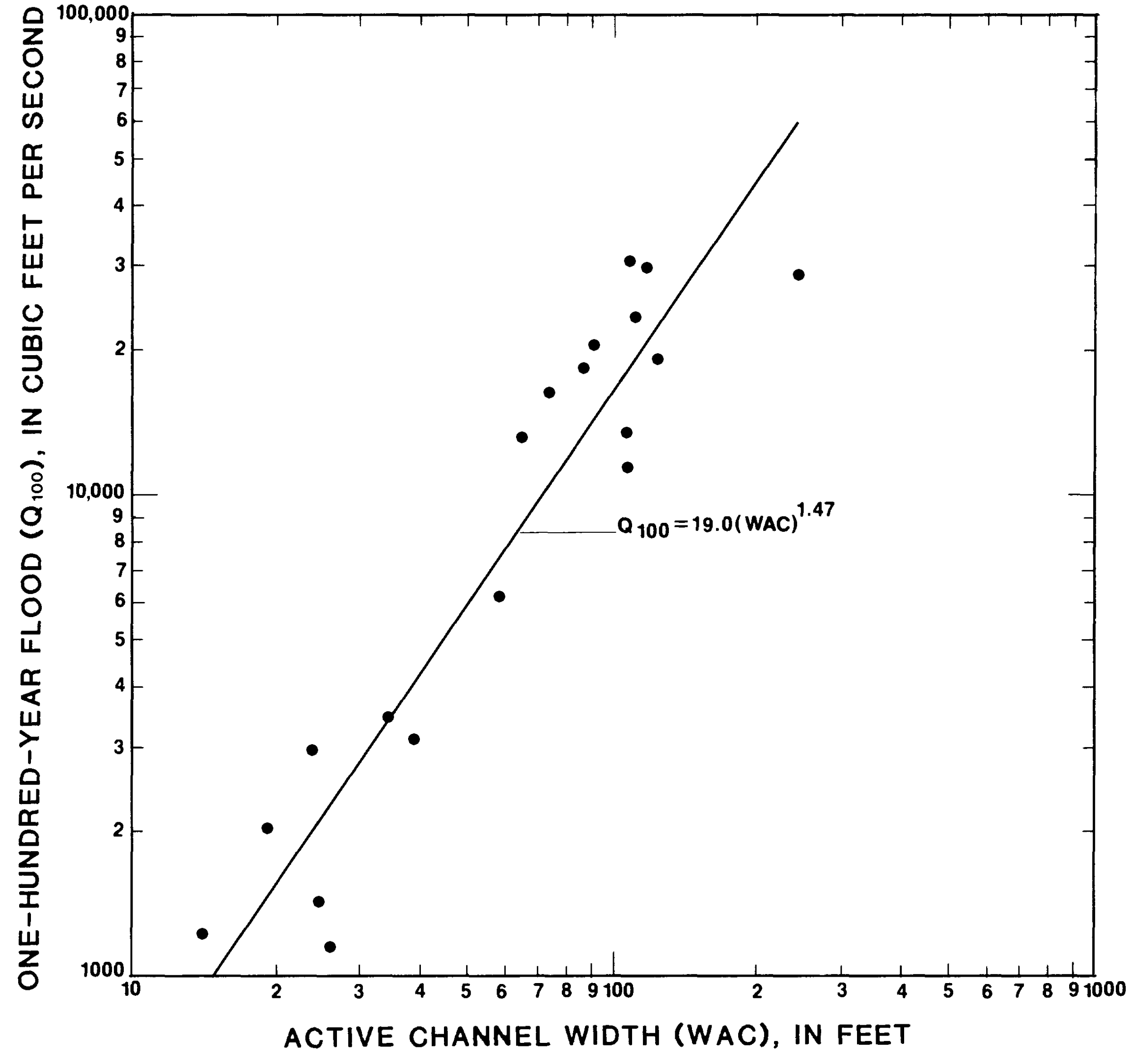


Figure 7.—Relation between active-channel width and flood-peak magnitude in bedrock channels, 100-year flood.

It is important to find a well defined bankfull channel in the proximity of a well defined active channel. If a well defined bankfull channel cannot be found, the equation with only one independent variable (WAC) should be used. In this example, equation 13 (table 5) would be used to estimate the 25-year flood at the site:

$$Q_{25} = 12.9\ (\text{WAC})^{1.50}$$

$$Q_{25} = 12.9\ (18.1)^{1.5}$$

$$Q_{25} = 993\ \text{ft}^3/\text{s}$$

The flood-frequency equations in this report are limited to unregulated, rural streams in Ohio. The alluvial channel estimating equations (Webber and Roberts, 1981) are based on data from watersheds with drainage areas ranging from 0.12 to 7,422 mi^2. Bedrock-channel estimating equations are based on data from watersheds with drainage areas ranging from 1.01 to 1,251 mi^2.

The average standard error of estimate, which is a measure of the distribution of the observed values around the line of regression, equals the average of the positive and negative departures, in percent. The average standard errors of estimate for alluvial-channel equations (Webber and Roberts, 1981), ranged from 42 percent for the 2-year flood to 55 percent for the 100-year flood. The average standard errors of estimate for bedrock-channel equations ranged from 36 percent for the 2-year flood to 46 percent for the 100-year flood when one variable (WAC) was used in the equation. When two variables (WAC and DBF) were used in the bedrock equations, the average standard error of estimate ranged from 33 percent for the 5-year flood to 40 percent for the 100-year flood.

The standard error of estimate for bedrock channels is reduced by 3 to 6 percent when the two-variable equations (WAC and DBF) are used. It is not always possible to find a good width of bankfull channel line (WBF) upon which the DBF is dependent in the area of the site. Therefore, the following is suggested in the selection of equations to use in bedrock channels: If a well defined bankfull channel is found in the vicinity of a well defined active channel at or near the site, it is suggested that the two-variable (WAC, DBF) equation be used for the 5-year flood through the 100-year flood. If only a well defined active-channel width (WAC) can be found at or near the site, it is suggested the one-variable (WAC) equation be used.

ADDITIONAL GENERATED FLOOD DATA

Ohio is generally well covered with streamflow stations, however, a deficiency of flow data in certain areas has made it difficult to use equations to estimate flood peaks. The difficulty is due to indistinct boundaries between some of the geographic areas delineated by Webber and Bartlett (1977). Each geographic area has a set of equations for estimating peak discharge from basin characteristics. Estimates of peak discharge would vary depending on which area equation was used. The south-central boundary between geographic areas 2 and 3, the north-central boundary between geographic areas 1 and 4, and the east-central boundary between geographic areas 2 and 5 (fig. 1) need improved definition.

In order to augment the available flood data near these boundaries, channel characteristics were measured at 168 ungaged stream sites (including 28 sites from the study by Webber and Roberts, 1981) and flood peaks were estimated by the equations presented in this report. The flood data generated by this method will allow the Ohio Department of Transportation to evaluate and (or) more clearly define the boundaries.

Active-channel width (WAC) was measured at 47 ungaged sites on streams west of the boundary between area 2 and 3; these data were compiled with data obtained by Webber and Roberts (1981) for 28 ungaged sites (fig. 8, tables 6 and 7). Channel characteristics were also determined for 58 ungaged sites in north-central Ohio near the boundary between areas 1 and 4 (fig. 9, tables 8 and 9) and 35 ungaged sites in east-central Ohio along the boundary between areas 2 and 5 (fig. 10, tables 10 and 11). WAC was measured at sites on streams with alluvial channels, whereas WAC and DBF were measured at sites on streams with bedrock channels.

Peak discharges for the 2-year and 100-year floods were estimated for each ungaged site. For alluvial channels, equations developed in Webber and Roberts (1981) and shown in this report were used. Equations developed as part of this study were used for bedrock channels. Equations found in Webber and Bartlett (1977) use basin characteristics rather than channel characteristics, and are defined for each geographic area shown in figure 1. Those equations were used to compute the 2-year and 100-year flood peaks for both geographic areas associated with each of the three study areas shown in figure 1. For example, for the easternmost study area shown on figure 1, the 2-year and 100-year flood peaks were computed using equations for geographic areas 2 and 5. The percentage differences between the peak discharges computed from channel characteristics equations and those computed from the two basin characteristics equations are shown in tables 7, 9, and 11. The ungaged site was said to more closely agree with whichever geographic areas's equations yielded the smaller percentage difference.

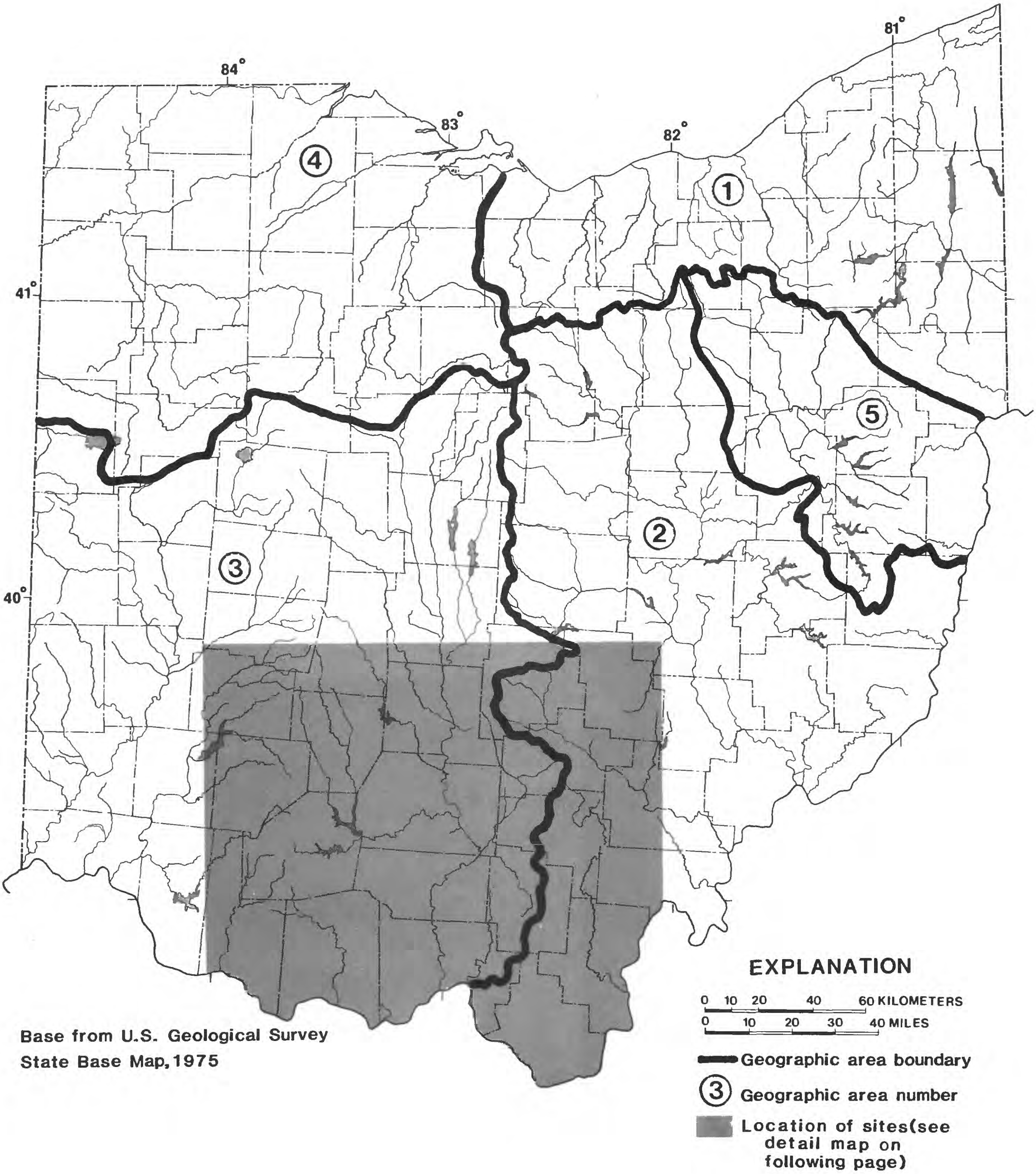
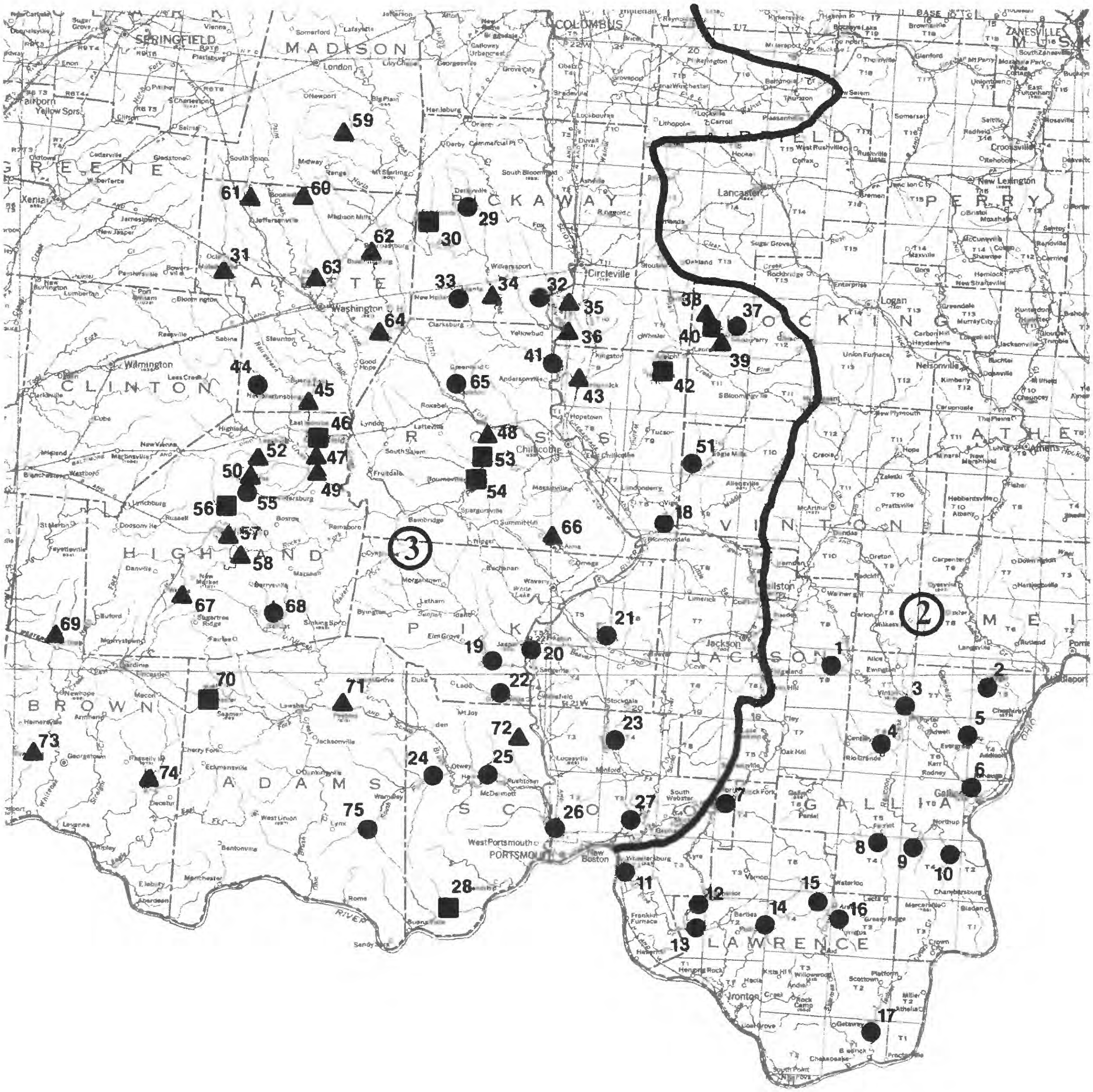


Figure 8.--Flood boundary in study areas 2 and 3, and location of ungaged sites in south-central Ohio.



Base from U.S. Geological Survey
State Base Map, 1975

0 10 20 30 40 MILES

0 10 20 30 40 KILOMETERS

EXPLANATION

Geographic-area boundary

(3) Geographic-area number

● 17 Site data more closely agree with geographic area 2

▲ 59 Site data more closely agree with geographic area 3

■ 28 Site data agree about equally with geographic areas 2 and 3

Figure 8.--Flood boundary in study areas 2 and 3, and location of ungaged sites in south-central Ohio--Continued.

Table 6.--Hydrologic data for ungaged sites in south-central Ohio near the boundary between geographic areas 2 and 3.

Site number (fig. 8)	Stream	Geographic area	Location: latitude longitude	Drainage area (mi^2)	Main-channel slope (ft/mi)	Average basin elevation (ft/1,000)	Average annual precipitation (inches -27)	Active-channel width (WAC) (ft)
1	Dickason Run	2	39°00'24" 82°28'12"	22.5	12	0.681	14	19
2	Jessie Creek	2	38°59'16" 82°09'02"	2.69	46	0.686	13.5	8
3	Little Raccoon Creek	2	38°57'11" 82°21'57"	154	3	0.655	13.5	50
4	Little Indian Creek	2	38°53'34" 82°22'58"	10.2	22	0.661	14	19
5	Campaign Creek	2	38°54'18" 82°13'10"	32.2	11	0.635	14	33
6	Chickamauga Creek	2	38°50'27" 82°13'18"	19.4	19	0.605	14	21
7	Brady Run	2	38°48'17" 82°39'16"	6.06	32	0.720	15	12.5
8	Sand Fork	2	38°44'54" 82°22'35"	37.1	8	0.687	14	25
9	Claylick Run	2	38°44'52" 82°18'14"	4.75	49	0.655	14	13
10	Bullskin Creek	2	38°43'33" 82°15'08"	13.1	28	0.628	14	22
11	Pine Creek	2	38°41'51" 82°50'50"	168	3	0.581	15.5	60
12	Pine Creek	2	38°39'14" 82°44'33"	102	4	0.614	15.5	38
13	Little Pine Creek	2	38°37'50" 82°43'54"	29.2	14	0.620	15.5	25
14	Paddle Creek	2	38°36'40" 82°35'27"	2.25	47	0.710	15	9.5
15	Aaron Creek	2	38°39'44" 82°29'26"	8.21	26	0.656	15	14

Table 6.--Hydrologic data for ungaged sites in south-central Ohio near the boundary between geographic areas 2 and 3.--Continued

Site number (fig. 8)	Stream	Geographic area	Location: latitude longitude	Drainage area (mi^2)	Main-channel slope (ft/mi)	Average basin elevation (ft/1,000)	Average annual precipitation (inches -27)	Active-channel width (WAC) (ft)
16	Long Creek	2	38°39'07" 82°27'57"	14.5	22	0.648	15	25
17	Indian Guyan Creek	2	38°28'42" 82°23'53"	67.5	6	0.619	15	40
18	Middle Fork Salt Creek	3	39°13'00" 82°45'46"	109	7	0.648	13.5	54
19	Sunfish Creek	3	39°00'46" 83°07'14"	136	8	0.628	13	76
20	Big Beaver Creek	3	39°01'54" 83°01'38"	68.9	6	0.595	13	43
21	Buck Hollow Creek	3	39°02'21" 82°51'56"	4.59	53	0.740	14	11
22	Camp Creek	3	38°58'26" 83°04'53"	26.7	56	0.770	13.5	32
23	McConnel Creek	3	38°53'16" 82°52'12"	10.1	20	0.678	14.5	17
24	Rocky Fork	3	38°51'03" 83°12'09"	22.8	40	0.760	14.5	33
25	Scioto Brush Creek	3	38°50'28" 83°05'45"	261	6	0.620	14.5	108
26	Carroll Run	3	38°46'08" 82°59'09"	0.434	277	0.665	15	5
27	Wards Run	3	38°46'03" 82°50'34"	7.36	29	0.610	15.5	16
28	McAtee Run	3	38°37'41" 83°09'34"	1.58	184	0.690	16	14
29	Buskirk Creek	3	39°39'36" 83°10'33"	11.6	11	0.868	10.5	13
30	Clark Run	3	39°39'02" 83°14'18"	5.47	8	0.878	10.5	9

Table 6.--Hydrologic data for ungaged sites in south-central Ohio near the boundary between geographic areas 2 and 3.--Continued

Site number (fig. 8)	Stream	Geographic area	Location: latitude longitude	Drainage area (mi^2)	Main channel slope (ft/mi)	Average basin elevation (ft/1,000)	Average annual precipitation (inches -27)	Active-channel width (WAC) (ft)
31	Grassy Branch	3	39°34'26" 83°37'00"	10.0	5	1.060	12	16
32	Lick Run	3	39°33'38" 83°00'07"	10.6	13	0.699	12	19
33	Hay Run	3	39°33'04" 83°09'47"	4.07	12	0.810	11	7.5
34	Little Yellowbud Creek	3	39°32'50" 83°04'06"	4.54	12	0.738	11.5	11
35	Scippo Creek	3	39°31'56" 82°57'57"	33.5	19	0.815	12	46
36	Congo Creek	3	39°30'30" 82°57'11"	11.0	10	0.710	12	22
37	Stump Run	3	39°30'09" 82°39'09"	2.28	68	0.883	12.5	8.5
38	Middle Fork Laurel Run	3	39°30'07" 82°42'02"	11.31	28	0.853	12.5	30
39	Laurel Run	3	39°29'44" 82°39'47"	6.60	35	0.850	12.5	18
40	Long Run	3	39°29'47" 82°41'07"	2.31	72	0.905	12.5	9.5
41	Blackwater Creek	3	39°27'37" 82°58'40"	5.68	20	0.703	12.5	13
42	Bull Creek	3	39°27'09" 83°46'46"	3.12	58	0.905	15	11
43	Kinnikinnick Creek	3	39°25'46" 82°56'22"	31.8	11	0.735	12.5	40
44	Lees Creek	3	39°24'10" 83°32'46"	20.3	6	1.040	14.5	16
45	Walnut Creek	3	39°23'05" 83°27'21"	5.42	25	0.952	13.5	14

Table 6.--Hydrologic data for ungaged sites in south-central Ohio near the boundary between geographic areas 2 and 3.--Continued

Site number (fig. 8)	Stream	Geo-graph-ic area	Location: latitude longitude	Drain-age area (mi^2)	Main-channel slope (ft/mi)	Aver-age basin eleva-tion (ft/1,000)	Average annual precipi-tation (inches -27)	Active-channel width (WAC) (ft)
46	Farmers Run	3	39°20'11" 83°23'44"	0.630	76	0.920	14	4.5
47	Sugar Run	3	39°20'03" 83°23'48"	3.35	42	0.930	14	14
48	Cattail Creek	3	39°19'53" 83°05'54"	2.54	89	0.825	12.5	15.5
49	Opossum Run	3	39°19'44" 83°24'41"	0.358	61	0.948	14	7.5
51	Bridgewater Creek	3	39°18'23" 83°31'20"	4.87	44	1.020	15	20.5
51	Pike Run	3	39°18'27" 82°43'52"	18.0	31	0.735	13	24
52	Bull Creek	3	39°18'26" 83°31'00"	4.06	36	0.990	15	15
53	Lower Twin Creek	3	39°16'58" 83°09'16"	16.5	48	0.903	13	26
54	Upper Twin Creek	3	39°16'41" 83°09'46"	14.2	31	0.795	13	26
55	Fall Creek	3	39°16'38" 83°33'50"	1.45	41	1.120	15.5	5.5
56	Clear Creek	3	39°14'15" 83°36'37"	23.2	34	1.040	15.5	49.5
57	Rocky Fork	3	39°11'00" 83°34'55"	19.0	22	0.988	16.5	33
58	South Fork	3	39°09'54" 83°34'55"	8.34	32	1.010	16.5	21.5
59	Bradford Creek	3	39°47'08" 83°23'01"	16.2	11.3	1.01	10.5	26.5
60	East Fork Paint Creek	3	39°41'26" 83°27'44"	13.7	10.2	1.05	11	23
61	Sugar Creek	3	39°41'35" 83°34'34"	17.1	7.9	1.09	11.5	23

Table 6.--Hydrologic data for ungaged sites in south-central Ohio near the boundary between geographic areas 2 and 3.--Continued

Site number (fig. 8)	Stream	Geographic area	Location: latitude longitude	Drainage area (mi^2)	Main-channel slope (ft/mi)	Average basin elevation (ft/1,000)	Average annual precipitation (inches -27)	Active-channel width (WAC) (ft)
62	Compton Creek	3	39°36'43" 83°20'41"	11.2	11.2	.960	11	18.5
63	Big Run	3	39°33'40" 83°26'11"	6.4	6.8	.984	11	15.5
64	Mills Branch	3	39°29'19" 83°19'07"	5.1	13.9	.903	11.5	11
65	Oldtown Run	3	39°25'09" 83°10'44"	7.2	34.4	.802	12.5	12
66	Crooked Creek	3	39°11'11" 82°58'54"	8.40	51.4	.742	12.5	29
67	Sugar Run	3	39°06'30" 83°40'36"	1.37	63	1.10	16	10.5
68	Middle Fork Ohio Brush	3	39°85'31" 83°27'32"	9.64	52.9	.858	15.5	19
69	Sterling Run	3	39°02'25" 83°55'08"	11.6	8.6	.945	14.5	23.5
70	Elm Fork	3	38°56'49" 83°37'21"	6.45	38	0.964	15.5	17
71	Stone Branch	3	38°57'03" 83°22'29"	0.85	76	0.827	14.5	7.5
72	Duncan Hollow Creek	3	38°52'29" 83°03'37"	0.51	276	0.937	14	6.0
73	East Branch Bullskin	3	38°51'59" 83°59'05"	2.95	35.4	0.918	14.5	12
74	Rattlesnake Creek	3	38°49'53" 83°43'24"	7.36	31.5	0.882	15	23.5
75	Churn Creek	3	38°46'40" 83°20'05"	17.9	51.4	0.782	15.5	34

Table 7.--Estimated 2-year and 100-year flood peaks for ungaged sites in south-central Ohio near the boundary between geographic areas 2 and 3

Site number (fig. 8)	Stream	Geographic area	[a]Type of channel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 2 equations (ft^3/s)	Difference, in percent	Computed Q_2 and Q_{100} from geographic area 3 equations (ft^3/s)	Difference, in percent
1	Dickason Run	2	A	781 2,910	905 3,530	16 21	2,210 7,570	182 160
2	Jessie Creek	2	A	251 1,070	223 1,310	-11 23	572 2,290	127 115
3	Little Raccoon Creek	2	A	2,770 8,950	3,100 7,780	12 -13	7,150 21,100	158 136
4	Little Indian Creek	2	A	781 2,910	550 2,610	-30 -10	1,450 5,270	86 81
5	Campaign Creek	2	A	1,610 5,530	1,180 4,550	-27 -18	3,170 10,500	97 90
6	Chickamauga Creek	2	A	890 3,270	891 4,130	0 26	2,640 9,050	197 177
7	Brady Run	2	A	451 1,790	394 2,110	-13 17	989 3,780	119 111
8	Sand Fork	2	A	1,120 4,000	1,230 4,220	10 5	2,900 9,580	159 140
9	Claylick Run	2	A	475 1,880	357 2,220	-25 19	995 3,850	109 105
10	Bullskin Creek	2	A	946 3,450	710 3,750	-25 9	2,020 7,250	114 110
11	Pine Creek	2	A	3,520 11,100	3,320 8,380	-6 -24	10,300 29,000	191 162
12	Pine Creek	2	A	1,940 6,510	2,380 6,530	23 0	6,890 20,400	256 213
13	Little Pine Creek	2	A	1,120 4,000	1,150 4,860	3 21	3,510 11,600	214 190
14	Paddle Creek	2	A	315 1,300	194 1,140	-38 -12	517 2,090	64 60
15	Aaron Creek	2	A	523 2,040	480 2,400	-8 17	1,370 5,010	162 145

Table 7.--Estimated 2-year and 100-year flood peaks for ungaged sites in south-central Ohio near the boundary between geographic areas 2 and 3--Continued

Site number (fig. 8)	Stream	Geographic area	[a]Type of channel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 2 equations (ft^3/s)	Difference, in percent	Computed Q_2 and Q_{100} from geographic area 3 equations (ft^3/s)	Difference, in percent
16	Long Creek	2	A	1,120 4,000	729 3,530	-35 -12	2,080 7,340	86 83
17	Indian Guyan Creek	2	A	2,070 6,910	1,870 5,890	-10 -15	5,320 16,400	157 137
18	Middle Fork Salt Creek	3	A	3,070 9,780	2,840 9,780	-7 0	6,840 21,200	123 117
19	Sunfish Creek	3	A	4,800 14,500	3,500 12,800	-27 -12	8,540 26,300	78 81
20	Big Beaver Creek	3	A	2,280 7,510	1,900 6,000	-17 -20	5,120 15,800	125 110
21	Buck Hollow Creek	3	A	382 1,540	353 2,270	-7 47	819 3,280	114 162
22	Camp Creek	3	A	1,550 5,330	1,470 10,600	-5 99	2,950 11,100	91 109
23	McConnel Creek	3	A	675 2,560	534 2,440	-21 -5	1,400 5,050	107 97
24	Rocky Fork	3	A	1,610 5,530	1,200 7,520	-25 36	2,600 9,630	61 74
25	Scioto Brush Creek	3	A	7,610 21,900	5,530 18,800	-27 -14	14,600 42,800	93 96
26	Carroll Run	3	A	136 619	77 836	-43 35	248 1,150	82 85
27	Wards Run	3	A	624 2,390	450 2,340	-28 -2	1,490 5,370	138 125
28	McAtee Run	3	A	523 2,040	199 1,960	-62 -4	604 2,610	15 28
29	Buskirk Creek	3	A	475 1,880	522 1,900	10 1	708 2,700	49 44
30	Clark Run	3	A	293 1,220	266 817	-9 -33	360 1,400	23 15

Table 7.--Estimated 2-year and 100-year flood peaks for ungaged sites in south-central Ohio near the boundary between geographic areas 2 and 3--Continued

Site number (fig. 8)	Stream	Geographic area	[a]Type of channel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 2 equations (ft^3/s)	Difference, in percent	Computed Q_2 and Q_{100} from geographic area 3 equations (ft^3/s)	Difference, in percent
31	Grassy Branch	3	A	624 2,390	388 1,020	-38 -57	426 1,640	-32 -31
32	Lick Run	3	A	781 2,910	499 1,900	-35 -33	1,070 3,870	37 33
33	Hay Run	3	A	231 991	230 815	-1 -18	372 1,460	61 47
34	Little Yellowbud Creek	3	A	382 1,540	251 896	-34 -42	485 1,840	27 19
35	Scippo Creek	3	A	2,490 8,120	1,380 6,600	-44 -19	2,250 8,190	-10 1
36	Congo Creek	3	A	946 3,450	489 1,710	-48 -51	1,010 3,610	6 5
37	Stump Run	3	A	272 1,150	213 1,450	-22 27	353 1,550	30 35
38	Middle Fork Laurel Run	3	A	1,420 4,950	631 3,310	-56 -33	1,030 4,030	-27 -19
39	Laurel Run	3	A	728 2,740	430 2,390	-41 -12	722 2,920	-1 7
40	Long Run	3	A	315 1,300	218 1,520	-31 17	348 1,540	10 18
41	Blackwater Creek	3	A	475 1,880	337 1,490	-29 -21	752 2,850	58 52
42	Bull Creek	3	A	382 1,540	265 1,720	-31 11	482 2,060	26 33
43	Kinnikinnick Creek	3	A	2,070 6,910	1,170 4,500	-43 -35	2,290 7,920	11 15
44	Lees Creek	3	A	624 2,390	713 2,110	14 -12	922 3,400	48 42
45	Walnut Creek	3	A	523 2,040	341 1,640	-35 -20	510 2,090	-2 2

Table 7.--Estimated 2-year and 100-year flood peaks for ungaged sites in south-central Ohio near the boundary between geographic areas 2 and 3--Continued

Site number (fig. 8)	Stream	Geographic area	[a]Type of channel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 2 equations (ft^3/s)	Difference, in percent	Computed Q_2 and Q_{100} from geographic area 3 equations (ft^3/s)	Difference, in percent
46	Farmers Run	3	A	118 548	77.9 517	-34 -6	138 645	17 18
47	Sugar Run	3	A	523 2,040	261 1,500	-50 -27	427 1,810	-18 -11
48	Cattail Creek	3	A	598 2,300	247 1,880	-59 -18	455 1,980	-24 -14
49	Opossum Run	3	A	231 991	47.1 278	-80 -72	80.9 385	-65 -61
50	Bridgewater Creek	3	A	863 3,180	355 2,130	-59 -33	528 2,250	-39 -29
51	Pike Run	3	A	1,060 3,820	937 5,250	-12 37	1,960 7,270	85 90
52	Bull Creek	3	A	573 2,210	294 1,600	-49 -27	458 1,930	-20 -13
53	Lower twin Creek	3	A	1,180 4,190	964 6,380	-18 52	1,490 5,930	26 41
54	Upper Twin Creek	3	A	1,180 4,190	775 4,280	-34 2	1,450 5,520	23 32
55	Fall Creek	3	A	154 691	132 723	-14 4	181 825	18 19
56	Clear Creek	3	A	2,740 8,840	1,170 6,900	-57 -22	1,650 6,490	-40 -27
57	Rocky Fork	3	A	1,610 5,530	906 4,470	-44 -19	1,440 5,530	-10 0
58	South Fork	3	A	918 3,360	509 2,770	-45 -18	811 3,290	-12 -2
59	Bradford Creek	3	A	1,210 4,280	686 2,570	-43 -40	730 2,850	-40 -33
60	East Fork Paint Creek	3	A	1,000 3,640	586 2,090	-42 -43	612 2,410	-39 -34
61	Sugar Creek	3	A	1,000 3,640	661 2,150	-34 -41	667 2,580	-33 -29

Table 7.--Estimated 2-year and 100-year flood peaks for ungaged sites in south-central Ohio near the boundary between geographic areas 2 and 3--Continued

Site number (fig. 8)	Stream	Geographic area	[a]Type of channel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 2 equations (ft^3/s)	Difference, in percent	Computed Q_2 and Q_{100} from geographic area 3 equations (ft^3/s)	Difference, in percent
62	Compton Creek	3	A	754 2,820	509 1,860	-32 -34	615 2,400	-18 -15
63	Big Run	3	A	598 2,300	291 846	-51 -63	341 1,340	-43 -42
64	Mills Branch	3	A	382 1,540	284 1,080	-25 -30	403 1,610	5 4
65	Oldtown Run	3	A	428 1,710	460 2,550	8 49	841 3,340	97 95
66	Crooked Creek	3	A	1,360 4,760	570 3,730	-58 -21	1,180 4,640	-13 -2
67	Sugar Run	3	A	359 1,464	139 895	-61 -39	203 939	-43 -36
68	Middle Fork Ohio Brush Creek	3	A	781 2,910	640 4,280	-18 47	1,250 5,000	60 72
69	Sterling Run	3	A	1,030 3,730	494 1,630	-52 -56	758 2,840	-27 -24
70	Elm Fork	3	A	675 2,560	431 2,470	-36 -4	708 2,910	5 14
71	Stone Branch	3	A	231 991	99.1 668	-57 -33	211 945	-9 -5
72	Duncan Hollow Creek	3	A	173 765	87.9 958	-49 25	156 785	-9 3
73	East Branch Bullskin Creek	3	A	428 1,710	226 1,210	47 29	389 1,640	-9 -4
74	Rattlesnake Creek	3	A	1,030 3,730	459 2,460	-56 -34	837 3,330	-19 -11
75	Churn Creek	3	A	1,670 5,720	1,040 7,140	-38 25	2,310 8,780	38 53

[a]A, Alluvial; R, bedrock
[b]Appropriate channel characteristics equations used.

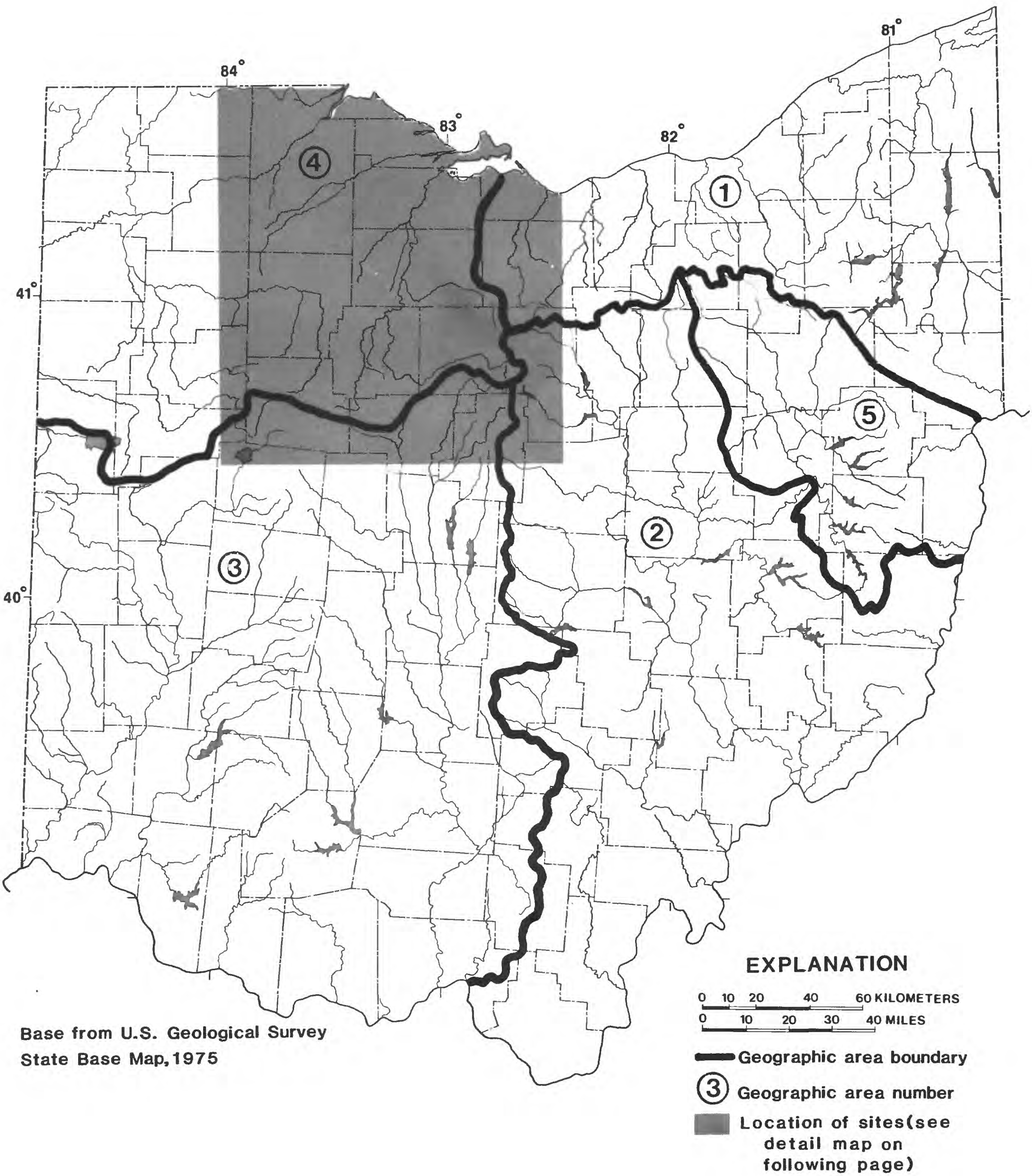


Figure 9.--Flood boundary in study areas 1 and 4, and location of ungaged sites in north-central Ohio.

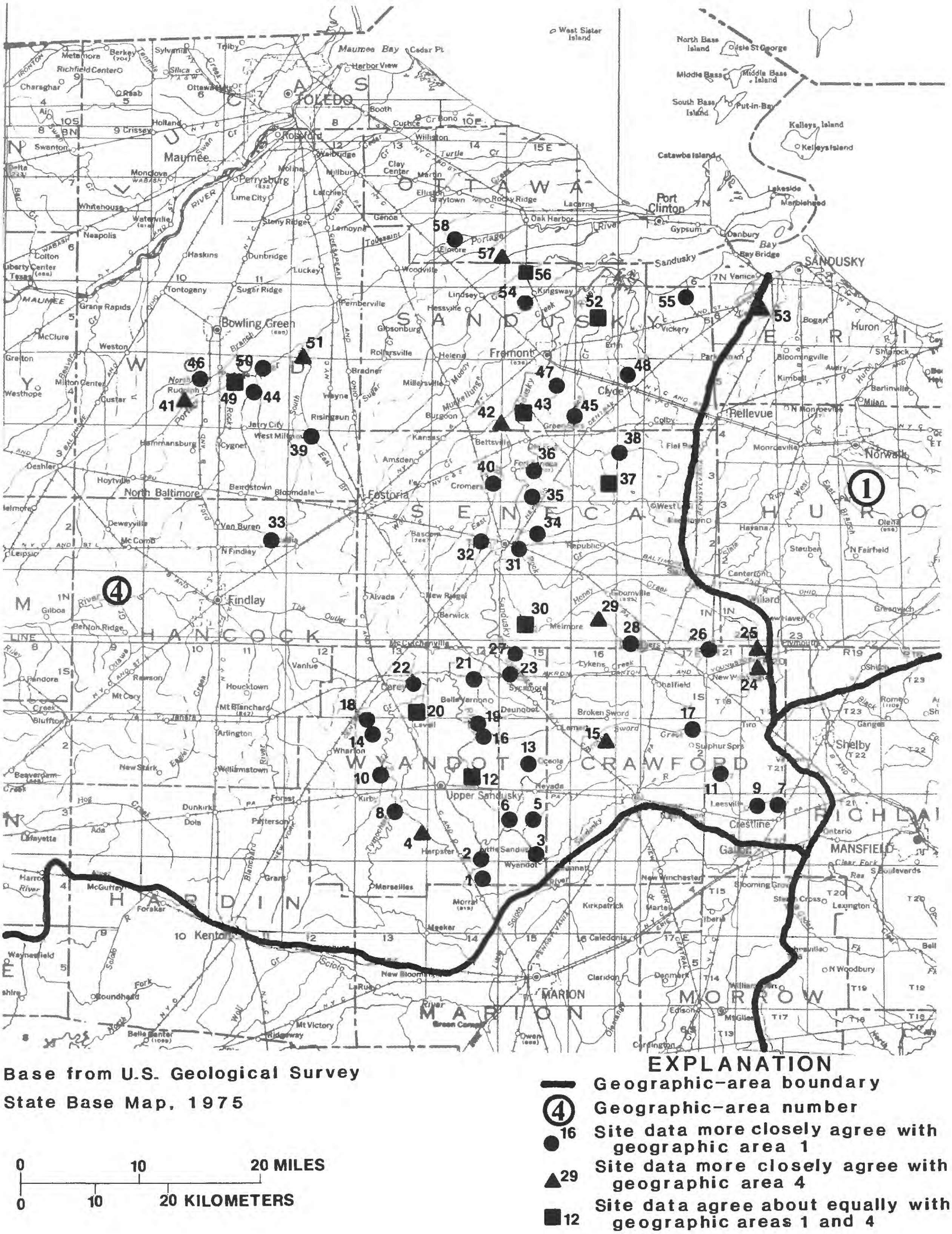


Figure 9.--Flood boundary in study areas 1 and 4, and location of ungaged sites in north-central Ohio--Continued.

Table 8.--Hydrologic data for ungaged sites in north-central Ohio near the boundary between geographic areas 1 and 4.

Site number (fig. 9)	Stream	Geo-graphic area	Location: latitude longitude	Drain-age area (mi^2)	Main-channel slope (ft/mi)	Average annual precipi-tation (inches -27 in.)	Surface storage, (in per-cent of drainage area plus 1.0 percent)	Active channel width (WAC) (ft)	Average depth of bankfull channel [a](DBF) (ft)
1	Honey Run	4	40°43'43" 83°12'28"	8.19	15	8	1	18.5	--
2	Little Sandusky River	4	40°44'17" 83°12'50"	37.7	2	8	3.5	30	--
3	Sandusky River	4	40°44'49" 83°07'46"	110	5	8.5	2	48	--
4	St. James Run	4	40°46'52" 83°18'11"	5.28	10	8	1.5	5.5	--
5	Grass Run	4	40°46'55" 83°07'56"	19.0	4	8.5	1.5	28	--
6	Broken Sword Creek	4	40°47'19" 83°09'41"	92.0	5	8.5	1.5	48	--
7	Paramour Creek Tributary	4	40°47'59" 82°45'28"	7.10	21	10	1	18	--
8	Warpole Creek	4	40°47'55" 83°21'11"	20.6	10	8	1	22	--
9	Paramour Creek	4	40°48'03" 82°45'56"	27.1	9	10	1	28	--
10	Perkins Run	4	40°50'01" 83°22'49"	5.28	12	8	1	11.5	--
11	Loss Creek	4	40°50'30" 82°49'07"	11.8	17	9.5	1.5	31.5	--
12	Rock Run	4	40°50'48" 83°14'28"	10.2	13	8.5	1.5	18.5	3.4
13	Indian Run	4	40°50'52" 83°07'52"	7.03	12	8.5	1.5	19	--
14	Baughman Run	4	40°52'54" 83°22'50"	4.43	15	8	1	13	--
15	Brandywine Creek	4	40°53'14" 83°01'06"	11.1	12	9	1.5	9	--

Table 8.--Hydrologic data for ungaged sites in north-central Ohio near the boundary between geographic areas 1 and 4.--Continued

Site number (fig. 9)	Stream	Geo-graphic area	Location: latitude longitude	Drain-age area (mi^2)	Main-channel slope (ft/mi)	Average annual precipi-tation (inches -27 in.)	Surface storage, (in per-cent of drainage area plus 1.0 percent)	Active channel width (WAC) (ft)	Average depth of bankfull channel [a](DBF) (ft)
16	Negro Run	4	40°53'20" 83°13'21"	13.1	18	8.5	1	26	--
17	Red Run	4	40°53'33" 82°52'07"	7.92	4	9	1.5	9.5	--
18	Lick Run	4	40°54'20" 83°22'50"	7.44	11	8	1	13	--
19	Sugar Run	4	40°54'10" 83°13'32"	4.62	21	8	1	14	--
20	Little Tymochtee Creek	4	40°55'10" 83°19'20"	35.0	3	8	1	19	--
21	Taylor Run	4	40°56'57" 83°12'22"	9.09	19	8.5	1	13	--
22	Poverty Run	4	40°57'11" 83°19'07"	11.4	7	8.5	1	14	--
23	Sycamore Creek	4	40°57'23" 83°10'12"	53.6	7	8.5	1	55	--
24	Honey Creek	4	40°58'57" 82°47'06"	16.7	14	9	1.5	13	--
25	Honey Creek	4	40°59'44" 82°47'10"	22.8	16	9	1	14	--
26	Brokenknife Creek	4	40°59'48" 82°50'32"	7.95	10	9	1.5	15	--
27	Mile Run	4	40°59'32" 83°10'17"	4.29	21	8.5	1	10.5	--
28	Silver Creek	4	40°59'46" 82°58'43"	9.81	5	8.5	2.5	10.5	--
29	Silver Creek	4	41°01'54" 83°02'03"	19.6	6	8.5	2	18	2.3
30	Honey Creek	4	41°01'48" 83°09'18"	165	5	8.5	1.5	51	--

Table 8.--Hydrologic data for ungaged sites in north-central Ohio near the boundary between geographic areas 1 and 4.--Continued

Site number (fig. 9)	Stream	Geo-graphic area	Location: latitude longitude	Drain-age area (mi^2)	Main-channel slope (ft/mi)	Average annual precipi-tation (inches -27 in.)	Surface storage, (in per-cent of drainage area plus 1.0 percent)	Active channel width (WAC) (ft)	Average depth of bankfull channel [a](DBF) (ft)
31	Willow Creek	4	41°07'13" 83°09'21"	5.29	14	8	1	18	--
32	East Branch East Branch Wolf Creek	4	41°07'43" 83°12'39	18.5	8	8	1.5	16	--
33	Rocky Ford	4	41°07'51" 83°34'44"	15.7	10	8	1	23	--
34	Morrison Creek	4	41°08'06" 83°08'35"	19.1	9	8	1	22	--
35	Spicer Creek	4	41°10'39" 83°08'16"	11.5	18	7.5	1	26.5	--
36	Sugar Creek	4	41°11'44" 83°07'25"	12.7	11	7.5	1	26.5	--
37	Westerhouse Ditch	4	41°12'00" 83°00'50"	15.4	13	7.5	1	15.5	--
38	Emerson Creek	4	41°13'47" 82°59'44"	21.6	8	7.5	1	19	--
39	East Branch Portage River	4	41°14'32" 83°29'36"	27.0	6	6.5	3	38.5	3.2
40	Snuff Creek	4	41°16'26" 83°11'51"	7.07	12	8	1	10	--
41	Middle Branch Portage River	4	41°16'44" 83°42'34"	68.7	5	6	1	27	--
42	Wolf Creek	4	41°16'12" 83°11'20"	72.6	6	7	1	47	1.6
43	Indian Creek	4	41°16'58" 83°09'13"	10.7	12	7	1	12	--
44	Bull Creek	4	41°17'51" 83°35'33"	20.2	6	6.5	1	16	--
45	Green Creek	4	41°17'17" 83°03'20"	15.1	9	8.5	1.5	34	--

Table 8.--Hydrologic data for ungaged sites in north-central Ohio near the boundary between geographic areas 1 and 4.--Continued

Site number (fig. 9)	Stream	Geo-graphic area	Location: latitude longitude	Drain-age area (mi^2)	Main-channel slope (ft/mi)	Average annual precipi-tation (inches -27 in.)	Surface storage, (in per-cent of drainage area plus 1.0 percent)	Active channel width (WAC) (ft)	Average depth of bankfull channel [a](DBF) (ft)
46	North Branch Portage River	4	41°18'43" 83°40'09"	24.5	2	5	1	16.5	--
47	Bark Creek	4	41°19'13" 83°05'17"	3.69	9	6.5	1	7	--
48	Buck Creek	4	41°19'43" 82°59'02"	3.82	20	6.5	1	7.5	--
49	Middle Branch Portage River	4	41°19'10" 83°35'35"	171	3	6.5	1	47	--
50	Middle Branch Portage River	4	41°19'32" 83°35'08"	207	3	6.5	1	63	--
51	South Branch Portage River	4	41°20'29" 83°30'18"	109	5	5.5	1.5	26	--
52	Green Creek	4	41°23'02" 83°01'38"	78.5	8	6	1.5	34	--
53	Mills Creek	1	41°23'29" 82°46'18"	28.2	10	6.5	1.5	23	1.7
54	Little Muddy Creek	4	41°24'35" 83°09'11"	14.6	9	5.5	1	18	--
55	Little Pickerel Creek	4	41°25'07" 82°53'13"	5.54	17	5.5	1.5	14.5	--
56	Muddy Creek	4	41°27'10" 83°08'37"	75.4	6	5.5	1	33	--
57	Ninemile Creek	4	41°28'06" 83°10'29"	12.4	8	5.5	1	9	--
58	Sugar Creek	4	41°28'18" 83°16'32"	56.3	5	5.5	1	30.5	--

[a]For bedrock channels only

Table 9.--Estimated 2-year and 100-year peak discharges for ungaged sites in north-central Ohio near the boundary between geographic areas 1 and 4.

Site number (fig. 9)	Stream	Geo-graph-ic area	[a]Type of chan-nel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 1 equations (ft^3/s)	Dif-ference, in percent	Computed Q_2 and Q_{100} from geographic area 4 equations (ft^3/s)	Dif-ference, in percent
1	Honey Run	4	A	754 2,820	472 1,710	-37 -39	319 887	-58 -69
2	Little Sandusky River	4	A	1,420 4,950	766 1,960	-46 -60	610 1,800	-57 -64
3	Sandusky River	4	A	2,630 8,530	2,480 6,900	-6 -19	2,150 5,140	-18 -40
4	St. James Run	4	A	154 691	275 938	79 36	195 585	27 -15
5	Grass Run	4	A	1,300 4,570	647 1,980	-50 -57	464 1,320	-64 -71
6	Broken Sword Creek	4	A	2,630 8,530	2,340 6,830	-11 -20	1,850 4,490	-30 -47
7	Paramour Creek Tributary	4	A	728 2,740	447 1,660	-39 -39	425 1,030	-42 -62
8	Warpole Creek	4	A	946 3,450	912 3,110	-4 -10	607 1,620	-36 -53
9	Paramour Creek	4	A	1,300 4,570	1,110 3,730	-14 -18	998 2,343	-23 -49
10	Perkins Run	4	A	405 1,630	320 1,170	-21 -28	206 608	-49 -63
11	Loss Creek	4	A	1,520 5,240	571 1,940	-62 -63	567 1,380	-63 -74
12	Rock Run	4	R	417 1,490	485 1,640	16 10	398 1,070	-5 -28
13	Indian Run	4	A	781 2,910	356 1,210	-54 -58	284 793	-64 -73
14	Baughman Run	4	A	475 1,880	289 1,080	-39 -43	191 560	-60 -70
15	Brandywine Creek	4	A	293 1,220	512 1,710	74 40	450 1,170	53 -4

Table 9.--Estimated 2-year and 100-year peak discharges for ungaged sites in north-central Ohio near the boundary between geographic areas 1 and 4.--Continued

Site number (fig. 9)	Stream	Geo-graph-ic area	[a]Type of chan-nel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 1 equations (ft^3/s)	Dif-ference, in percent	Computed Q_2 and Q_{100} from geographic area 4 equations (ft^3/s)	Dif-ference, in percent
16	Negro Run	4	A	1,180 4,190	706 2,540	-40 -39	542 1,380	-54 -67
17	Red Run	4	A	315 1,300	324 1,030	3 -21	241 717	-23 -45
18	Lick Run	4	A	475 1,880	414 1,480	-13 -21	267 772	-44 -59
19	Sugar Run	4	A	523 2,040	318 1,200	-39 -41	220 621	-58 -70
20	Little Tymochtee Creek	4	A	781 2,910	1,120 3,490	44 20	650 1,860	-17 -36
21	Taylor Run	4	A	475 1,880	534 1,950	12 4	406 1,060	-14 -43
22	Poverty Run	4	A	523 2,040	537 1,830	3 -10	360 1,010	-31 -50
23	Sycamore Creek	4	A	3,140 9,990	1,830 5,870	-42 -41	1,310 3,220	-58 -68
24	Honey Creek	4	A	475 1,880	726 2,410	53 29	663 1,640	40 -12
25	Honey Creek	4	A	523 2,040	1,070 3,750	105 83	896 2,130	71 4
26	Brokenknife Creek	4	A	573 2,210	381 1,280	-34 -42	322 877	-44 -60
27	Mile Run	4	A	359 1,460	300 1,140	-16 -22	224 618	-38 -58
28	Silver Creek	4	A	359 1,460	342 1,020	-5 -30	286 842	-20 -42
29	Silver Creek	4	R	319 973	653 1,970	105 102	540 1,470	69 51
30	Honey Creek	4	A	2,850 9,160	3,720 10,600	30 16	3,010 6,960	6 -24

Table 9.--Estimated 2-year and 100-year peak discharges for ungaged sites in north-central Ohio near the boundary between geographic areas 1 and 4.--Continued

Site number (fig. 9)	Stream	Geographic area	[a]Type of channel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 2 equations (ft^3/s)	Difference, in percent	Computed Q_2 and Q_{100} and geographic area 3 equations (ft^3/s)	Difference, in percent
31	Willow Creek	4	A	728 2,740	330 1,210	-55 -56	217 630	-70 -77
32	East Branch Wolf Creek	4	A	624 2,390	714 2,280	15 -4	518 1,420	-17 -40
33	Rocky Ford	4	A	1,000 3,640	736 2,530	-27 -30	484 1,320	50 -63
34	Morrison Creek	4	A	946 3,450	843 2,860	-11 -17	552 1,500	-42 -57
35	Spicer Creek	4	A	1,210 4,280	637 2,300	-47 -46	411 1,130	-66 -74
36	Sugar Creek	4	A	1,210 4,280	632 2,210	-48 -48	383 1,090	-68 -75
37	Westerhouse Ditch	4	A	598 2,300	758 2,660	27 16	474 1,310	-21 -43
38	Emerson Creek	4	A	781 2,910	910 3,060	17 5	540 1,510	-31 -48
39	East Branch Portage River	4	R	1,060 2,890	746 2,100	-29 -27	491 1,490	-54 -48
40	Snuff Creek	4	A	337 1,380	404 1,450	20 5	263 757	-22 -45
41	Middle Branch Portage River	4	A	1,240 4,380	2,100 6,530	69 49	907 2,700	-27 -38
42	Wolf Creek	4	R	914 1,730	2,260 7,110	147 310	1,240 3,330	35 92
43	Indian Creek	4	A	428 1,710	561 1,980	31 16	311 923	-27 -46
44	Bull Creek	4	A	624 2,390	821 2,720	32 14	385 1,200	-38 -50
45	Green Creek	4	A	1,670 5,720	621 2,020	-63 -65	492 1,320	-71 -77

Table 9.--Estimated 2-year and 100-year peak discharges for ungaged sites in north-central Ohio near the boundary between geographic areas 1 and 4.--Continued

Site number (fig. 9)	Stream	Geographic area	[a]Type of channel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 1 equations (ft^3/s)	Difference, in percent	Computed Q_2 and Q_{100} from geographic area 4 equations (ft^3/s)	Difference, in percent
46	North Branch Portage	4	A	649	790	22	226	-65
				2,470	2,430	-2	878	-65
47	Bark Creek	4	A	211	230	9	106	-50
				915	832	-9	367	-60
48	Buck Creek	4	A	231	271	17	139	-40
				991	1,030	4	448	-55
49	Middle Branch Portage River	4	A	2,560	3,940	54	1,840	-28
				8,330	11,500	38	5,110	-39
50	Middle Branch Portage River	4	A	3,760	4,590	22	2,160	-42
				11,700	13,300	14	5,890	-50
51	South Branch Portage River	4	A	1,180	2,680	127	1,180	1
				4,190	7,760	85	3,540	-16
52	Green Creek	4	A	1,670	2,240	34	1,170	-30
				5,720	6,770	18	3,300	-42
53	Mills Creek	1	R	369	1,040	181	596	62
				911	3,300	263	1,720	89
54	Little Muddy Creek	4	A	728	682	-6	266	-63
				2,740	2,340	-14	893	-67
55	Little Pickerel Creek	4	A	548	314	-43	144	-74
				2,130	1,100	-48	497	-77
56	Muddy Creek	4	A	1,610	2,330	45	922	-43
				5,530	7,310	32	2,800	-49
57	Ninemile Creek	4	A	293	587	100	224	-24
				1,220	2,010	64	771	-37
58	Sugar Creek	4	A	1,450	1,790	23	683	-53
				5,040	5,620	12	2,160	-57

[a]A, alluvial; R, bedrock.
[b]Appropiate channel characteristics equation used.
Single independent-varialbe (WAC) equations used for bedrock streams.

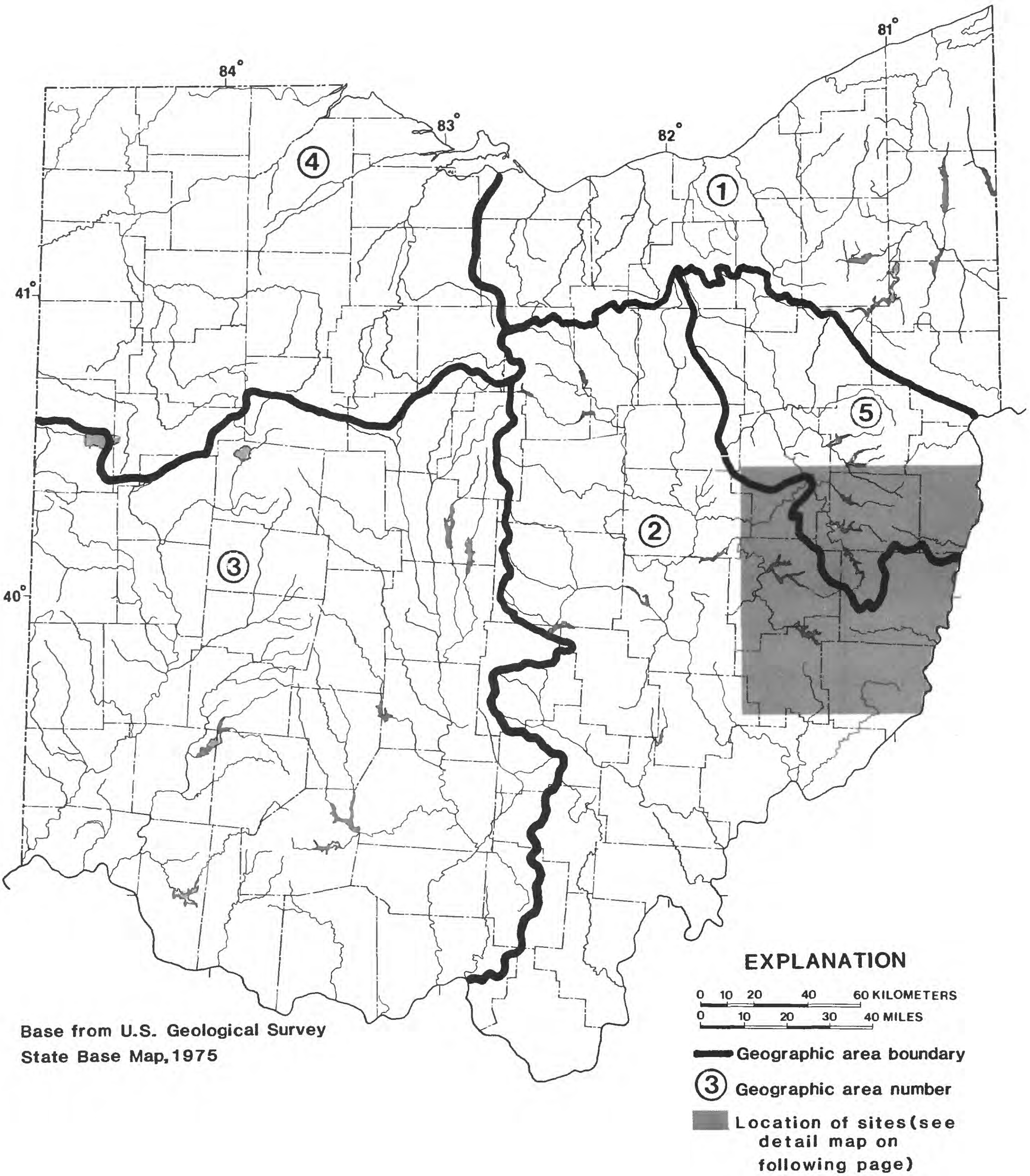
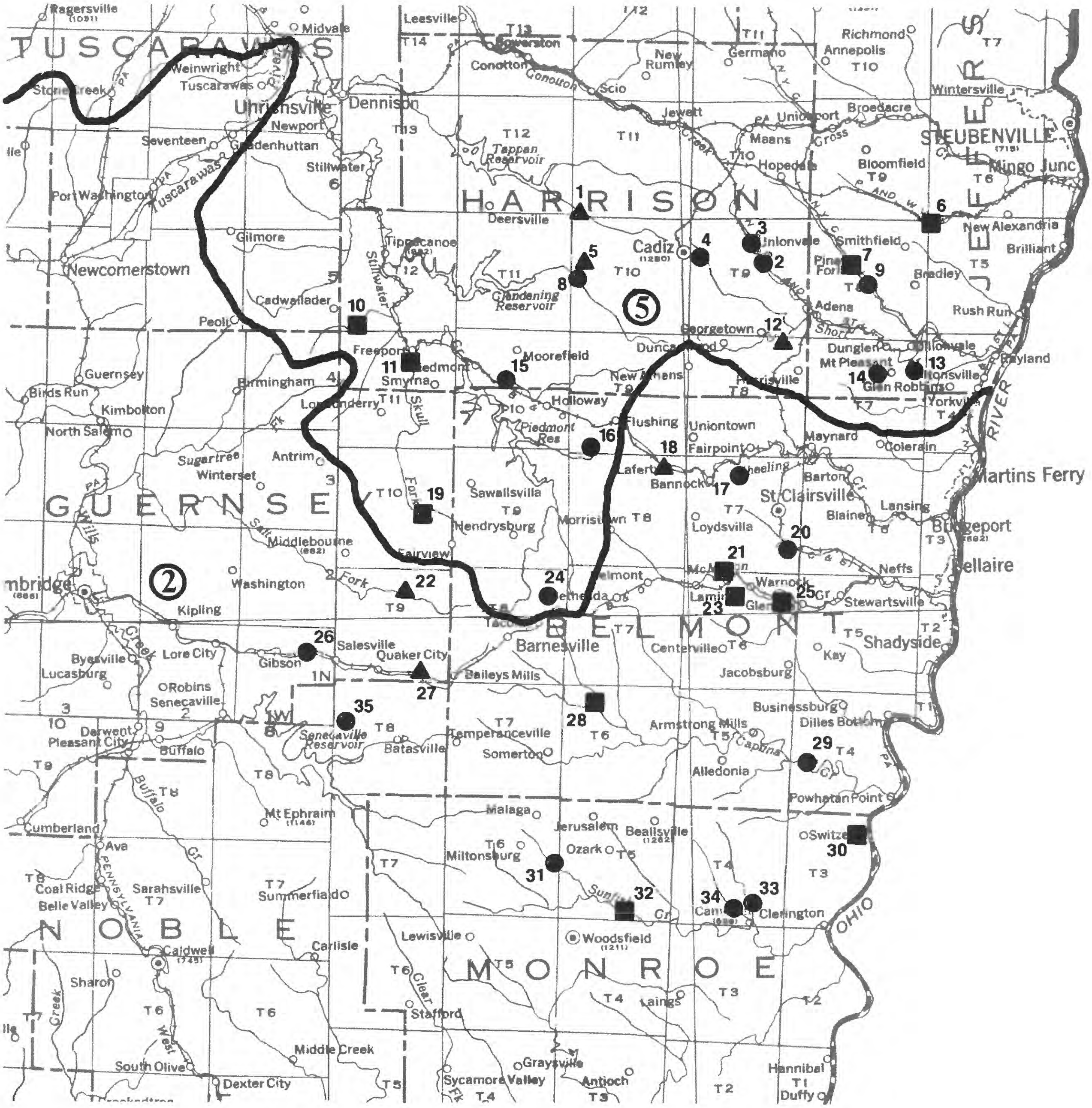


Figure 10.--Flood boundary in study areas 2 and 5, and location of ungaged sites in east-central Ohio.



Base from U.S. Geological Survey
State Base Map, 1975

0 10 20 MILES
0 10 20 KILOMETERS

EXPLANATION

Geographic-area boundary

⑤ Geographic-area number

● 9 Site data more closely agree with geographic area 2

▲ 22 Site data more closely agree with geographic area 5

■ 32 Site data agree about equally with geographic areas 2 and 5

Figure 10.--Flood boundary in study areas 2 and 5, and location of ungaged sites in east-central Ohio--Continued.

Table 10.--Hydrologic data for ungaged sites in east-central Ohio near the boundary between geographic areas 2 and 5.

Site number (fig. 10)	Stream	Geo-graphic area	Location: latitude longitude	Drain-age area (mi^2)	Main-channel slope (ft/mi)	Active-channel width (WAC) (ft)	Average depth bankfull channel [a](DBF) (ft)
1	Standing Fork	5	40°17'54" 80°05'06"	8.94	36	13	--
2	Harmon Creek	5	40°16'24" 80°55'36"	3.06	42	10.5	--
3	North Fork Short Creek	5	40°16'22" 80°55'38"	7.83	43	18	--
4	Liming Creek	5	40°16'14" 80°58'42"	1.57	53	7.5	--
5	Lees Run	5	40°15'50" 80°05'15	2.78	102	5	--
6	McIntyre Creek	5	40°15'15" 80°17'16"	14.4	34	21	--
7	Piney Fork	5	40°15'14" 80°49'25"	16.3	31	22	--
8	Brush Fork	5	40°15'07" 81°06'19"	18.1	18	21	--
9	Cabbage Run	5	40°14'42" 80°48'49"	1.73	80	15	--
10	Atkinson Creek	5	40°13'12" 81°19'17"	8.54	40	14	--
11	Stillwater Creek	5	40°12'16" 81°16'21"	177	4	48	--
12	South Fork Short Creek	5	40°12'12" 80°54'29"	12.3	36	14	--
13	Short Creek	5	40°11'49" 80°48'32"	127	4	48	--
14	Long Run	5	40°11'24" 80°49'44"	4.61	86	19	--
15	Boggs Fork	5	40°10'41" 81°10'46"	26.8	11	28	--
16	Trail Run	5	40°08'26" 81°05'44"	1.92	92	10	--
17	Pogue Run	2	40°06'38" 80°55'56"	4.46	56.5	17.5	--
18	Wheeling Creek	2	40°06'37" 83°22'50"	4.17	46	8.5	--

Table 10.--Hydrologic data for ungaged sites in east-central Ohio near the boundary between geographic areas 2 and 5--Continued

Site number (fig. 10)	Stream	Geographic area	Location: latitude longitude	Drainage area (mi^2)	Main-channel slope (ft/mi)	Active-channel width (WAC) (ft)	Average depth bankfull channel [a](DBF) (ft)
19	Skull Fork	5	40°04'58" 81°15'49"	4.76	44	11	--
20	Little McMahon Creek	2	40°02'54" 80°43'55"	4.39	55	26	--
21	Brush Run	2	40°01'56" 80°57'13"	3.70	62	11	--
22	Salt Fork Tributary	2	40°01'25" 81°16'52"	6.61	33	9.5	--
23	Hutchison Run	2	40°01'06" 80°56'25"	1.04	130	6	--
24	Spencer Creek	5	40°01'01" 81°09'29"	3.46	63	15	--
25	McMahon Creek	2	40°00'50" 80°54'55"	32.4	17	40	4.4
26	Leatherwood Creek	2	39°58'40" 81°21'56"	35.6	13	27	--
27	Shannon Run	2	39°57'48" 81°16'02"	4.45	55	7	--
28	Long Run	2	39°55'59" 81°05°10"	10.6	43	19	--
29	Moore Run	2	39°53'43" 80°52'41"	3.97	116	20	--
30	Big Run	2	39°50'13" 80°49'47"	4.13	128	16	--
31	Baker Fork	2	39°49'13" 81°08'01"	5.10	47	14	--
32	Sunfish Creek	2	39°46'51" 81°03'37	43.3	13	48	3.4
33	Paine Run	2	39°46'30" 80°56'18"	7.95	71	23	--
34	Ackerson Run	2	39°46'26" 80°56'40"	6.45	68	23	--
35	Yoker Creek	2	39°55'45" 81°19'44"	1.07	132	8.5	--

[a]For bedrock channels only

Table 11.--Estimated 2-year and 100-year peak discharges for ungaged sites in north-central Ohio near the boundary between geographic areas 2 and 5

Site number (fig. 10)	Stream	Geographic area	[a]Type of channel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 2 equations (ft^3/s)	Difference, in percent	Computed Q_2 and Q_{100} from geographic area 5 equations (ft^3/s)	Difference, in percent
1	Standing Fork	5	A	475 1,880	553 3,160	16 68	427 1,690	-10 -10
2	Harmon Creek	5	A	359 1,460	242 1,390	-33 -5	195 858	-46 -41
3	North Fork Short Creek	5	A	728 2,740	517 3,150	-29 15	408 1,640	-44 -40
4	Liming Creek	5	A	231 991	149 904	-35 -9	125 589	-46 -41
5	Lees Run	5	A	136 619	274 2,210	102 257	240 1,080	77 75
6	McIntyre Creek	5	A	890 3,270	800 4,590	-10 40	607 2,300	-32 -30
7	Piney Fork	5	A	946 3,450	865 4,820	-9 40	648 2,420	-31 -30
8	Brush Fork	5	A	890 3,270	833 3,770	-6 15	592 2,170	-34 -34
9	Cabbage Run	5	A	573 2,210	177 1,270	-69 -43	154 722	-73 -67
10	Atkinson Creek	5	A	523 2,040	546 3,240	4 59	426 1,700	-19 -17
11	Stillwater Creek	5	A	2,630 8,530	3,700 10,480	41 23	2,150 6,200	-18 -27
12	South Fork Short Creek	5	A	523 2,040	714 4,150	36 103	547 2,100	4 3
13	Short Creek	5	A	2,630 8,530	2,830 7,880	8 -8	1,660 4,940	-37 -42
14	Long Run	5	A	781 2,910	395 3,070	-49 5	337 1,440	-57 -50
15	Boggs Fork	5	A	1,300 4,570	1,020 3,890	-21 -15	686 2,400	-47 -47

Table 11.--Estimated 2-year and 100-year peak discharges for ungaged sites in north-central Ohio near the boundary between geographic areas 2 and 5--Continued

Site number (fig. 10)	Stream	Geographic area	[a]Type of channel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 2 equations (ft^3/s)	Difference, in percent	Computed Q_2 and Q_{100} from geographic area 5 equations (ft^3/s)	Difference, in percent
16	Trail Run	5	A	337 1,380	199 1,510	-41 9	174 813	-48 -41
17	Pogue Run	2	A	701 2,650	350 2,300	-50 -13	287 1,230	-59 -54
18	Wheeling Creek	2	A	272 1,150	317 1,910	16 67	255 1,090	-6 -5
19	Skull Fork	5	A	382 1,540	349 2,080	-9 35	279 1,180	-27 -24
20	Little McMahon Creek	2	A	1,180 4,190	344 2,230	-71 -47	281 1,200	-76 -71
21	Brush Run	2	A	382 1,540	308 2,080	-19 34	256 1,110	-33 -28
22	Salt Fork Tributary	2	A	315 1,300	425 2,310	35 77	329 1,340	4 3
23	Hutchison Run	2	A	173 765	131 1,110	-24 45	121 601	-30 -21
24	Spencer Creek	5	A	573 2,210	293 1,980	-49 -11	244 1,070	-57 -52
25	McMahon Creek	2	R	1,340 4,150	1,310 5,990	-2 44	913 3,170	-32 -24
26	Leatherwood Creek	2	A	1,240 4,380	1,330 5,500	8 26	902 3,080	-27 -30
27	Shannon Run	2	A	211 915	348 2,260	65 147	284 1,210	35 33
28	Long Run	2	A	781 2,910	660 4,080	-16 40	515 2,020	-34 -31
29	Moore Run	2	A	835 3,090	375 3,250	-55 5	330 1,140	-60 -53
30	Big Run	2	A	624 2,390	396 3,570	-37 50	351 1,530	-44 -36

Table 11.--Estimated 2-year and 100-year peak discharges for ungaged sites in north-central Ohio near the boundary between geographic areas 2 and 5--Continued

Site number (fig. 10)	Stream	Geographic area	[a]Type of channel	[b]Computed Q_2 and Q_{100} (ft^3/s)	Computed Q_2 and Q_{100} from geographic area 2 equations (ft^3/s)	Difference, in percent	Computed Q_2 and Q_{100} from geographic area 5 equations (ft^3/s)	Difference, in percent
31	Baker Fork	2	A	523	374	-29	301	-43
				2,040	2,300	13	1,260	-38
32	Sunfish Creek	2	R	1,470	1,560	6	1,050	-28
				3,820	6,500	70	3,530	-8
33	Paine Run	2	A	1,000	586	-42	483	-52
				3,640	4,350	20	1,960	-46
34	Ackerson Run	2	A	1,000	491	-51	405	-60
				3,640	3,540	-3	1,680	-54
35	Yoker Creek	2	A	272	135	-50	124	-54
				1,150	1,140	0	616	-46

[a]A, Alluvial; R, Bedrock

[b]Appropriate channel characteristics equations used.
Single independent-variable (WAC) equations used in bedrock streams.

SUMMARY AND CONCLUSIONS

Active-channel width (WAC) was found by regression analysis to be the most significant channel-geometry characteristic controlling flood-peak discharges in alluvial channels. The analysis was based on data from gaging stations that have 10 or more years of record with natural flow. In addition, several median grain-size characteristics were found to be statistically significant at the 5-percent level as independent variables in the regression analyses. However, standard errors of estimate were not greatly improved over those from equations based on WAC alone; inclusion of median grain-size characteristics in equations for estimating peak discharge on streams with alluvial channels is therefore unwarranted. Equations developed by Webber and Roberts (1981, p. 14) are recommended for alluvial channels.

Multiple-regression equations were developed for bedrock channels that relate peak discharge to active-channel width (WAC) and average depth of bankfull channel (DBF). The equations were based on data from 20 gaging stations. WAC ranged from 14 to 240 feet and DBF ranged from 2.5 to 9.2 feet. Standard errors of estimate for the bedrock equations range from 33 to 40 percent when both independent variables are used.

The equations developed by Webber and Roberts (1981) and those developed in this study are not meant to replace the equations developed by Webber and Bartlett (1977), which are still recommended for estimating flood magnitudes and frequencies. The equations based on channel characteristics are intended as supplements, and are advantageous when a flood estimate is needed that is independent of geographic-area boundaries and traditional basin characteristics.

Channel characteristics were measured at ungaged sites and peak-discharge values were determined in areas where geographic-area boundaries may need to be refined. The boundaries that may need refinement are in south-central Ohio, in north-central Ohio, and in east-central Ohio (fig. 1). The actual refinement of geographic-area boundaries is beyond the scope of this report.

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