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Water-Resources Investigations 34-74

ESTIMATING STREAMFLOW CHARACTERISTICS FOR STREAMS IN UTAH USING SELECTED CHANNEL-GEOMETRY PARAMETERS

Prepared in cooperation with
Utah Department of Highways

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METRIC UNITS

Most numbers are given in this report in English units followed by metric units in parentheses. The conversion factors used are:

English Unit (Multiply)	English Abbreviation	(by)	Metric Unit (to obtain)	Metric Abbreviation
Acre-feet	(acre-ft)	0.0012335	Cubic hectometres	(hm^3)
Cubic feet	(ft^3)	.02832	Cubic metres	(m^3)
Feet	(ft)	.3048	Metres	(m)

ESTIMATING STREAMFLOW CHARACTERISTICS FOR STREAMS

IN UTAH USING SELECTED CHANNEL-GEOMETRY PARAMETERS

By Fred K. Fields

ABSTRACT

Channel-geometry parameters are related to mean annual streamflow and the 25- and 50-year recurrence-interval flood discharges of Utah streams.

Channel width and depth between depositional bars can be used to estimate mean annual streamflow for perennial streams with a standard error of estimate of 34 percent. The standard error of estimate of mean annual streamflow for ephemeral streams is 73 percent.

The 25- and 50-year floods on perennial and ephemeral streams can be estimated from the channel width between depositional bars with standard errors of estimate ranging from 28 to 43 percent.

INTRODUCTION

An appraisal of the streamflow characteristics of an area is a significant part of many hydrologic investigations. Determination of average water yields is necessary for the optimum evaluation and development of streamflow; and peak flood-discharge rates are needed for the design of channels, bridges, and culverts. The first step in appraising the streamflow characteristics of an area is to examine the existing data base. Streamflow information is seldom available for all possible points of interest; and a simple, inexpensive method is needed to estimate streamflow characteristics at ungaged points. Therefore, an investigation was undertaken by the U.S. Geological Survey in cooperation with the Utah Department of Highways to test the usefulness of channel-geometry measurements in making estimates of mean annual streamflow and peak flood discharges for floods with 25- and 50-year recurrence intervals at ungaged sites in Utah. This report describes the parameters than can be used to estimate mean annual streamflow and flood discharges, the estimating equations, and the expected accuracy levels of the estimates.

Channel measurements were made at 57 sites in Utah and Idaho. Measurements from 14 sites in California and Nevada were added to obtain an enlarged sample of ephemeral streamflow.

Estimating equations were defined through multiple-regression techniques from information collected at streamflow gaging sites operated by the Geological Survey on unregulated natural streams. The streamflow data used in the development of estimating equations conform to several stipulations: (1) only those sites with at least 8 years of record were included in the derivation of relations to estimate mean annual streamflow; (2) only those sites with at least 15 to 20 annual maximum discharge determinations were considered in developing equations for estimating the 25- and 50-year recurrence-interval flood discharges, respectively; and (3) only records collected through September 1970 were used.

All the equations relating the selected streamflow characteristics to channel-geometry parameters were defined by multiple-regression techniques. Each estimate made with one of these equations is subject to error. This error is expressed in percent of the dependent variable in the equations, which is the mean annual streamflow or a flood discharge. A standard error of estimate of "x" percent indicates that two-thirds of the sample values fall within $\pm x$ percent of the relation.

RECENT INVESTIGATIONS

Two studies were made in 1971 with multiple-regression techniques. Mean annual flow and flood discharges for recurrence intervals of 5, 10, 25, and 50 years were related to basin characteristics.

Whitaker (1971, p. 10) found that if the collection period at a specific site is 5 years, then the standard error of estimate for the 50-year flood is about 60 percent. The standard error of estimate for the mean annual streamflow of a perennial stream is about 20 percent for a 5-year period of record. Whitaker also found that mean annual flow can be estimated with an error of 58 percent within the State. The standard error of estimate of the 25- and 50-year recurrence-interval flood equations was 50 and 58 percent, respectively. However, flood-frequency equations apply only to about 10 percent of the State.

Butler and Cruff (1971) examined the 5- and 10-year recurrence-interval floods of 284 gaging sites in Utah. They developed estimating equations for four distinct areas within Utah with standard errors of estimate ranging from about 50 to 120 percent.

These investigations demonstrated the applicability of multiple-regression techniques in providing simple estimating equations.

THE SELECTED CHANNEL-GEOMETRY PARAMETERS

The parameters used for these channel-geometry measurements are width and depth of the section between depositional bars. These channel bars are formed by the accumulation of sediment along the entire length of the channel as the stream velocity decreases during flood-peak and snowmelt recessions. The channel bars are the first continuous features that appear above the streambed, they extend along the channel edges, and they consist of materials that on the whole are finer grained than the materials that form the floor of the channel. The crests of the bars are flat and parallel to the water surface or channel floor. The channel bars slope upward and away from the stream until the crest is reached; and the streamward edges of the crests at the breaks in slope are the ends of the channel-geometry section. The crests are about 0.2 to 0.5 foot (0.06 to 0.15 m) above the water surface of a perennial stream during late summer and fall and are generally 0.2 to 1.0 foot (0.06 to 0.30 m) above the streambed of an ephemeral stream. As shown in figure 1, the channel width is the distance between the bars. The depth is the average of at least 12 to 15 measurements spaced uniformly across the section below a line connecting the section edges.

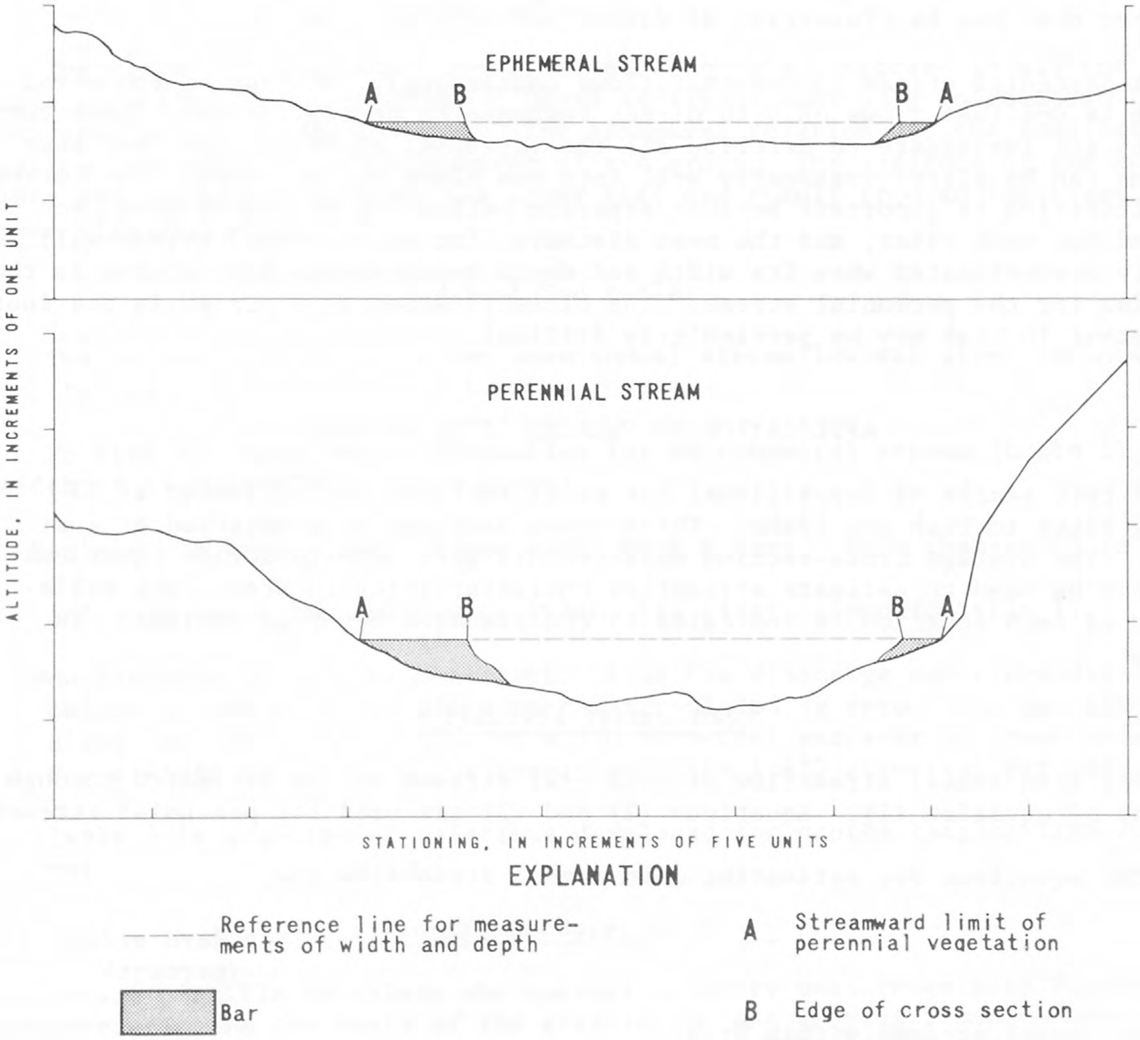

Figure 1.— Cross sections of typical ephemeral and perennial streams.

Three cross sections were measured at most sites to obtain parameter values that are more representative than those of a single section.

The following features may improve the accuracy of the measurements: a straight uniform reach, gentle side slopes within the channel, no localized disturbances that would disrupt the normal flow lines, and moderate velocity of flow within the cross section.

The measurements of width and depth of the section between depositional or other bars have been successfully related to mean annual streamflow characteristics in California (Hedman, 1970), Colorado (Hedman, Moore, and Livingston, 1972), Kansas (Hedman and Kaster, 1972), and Nevada (Moore, 1968). Reliable estimates of mean annual streamflow can be made when the section is measured on a stream that can be classified as either perennial or ephemeral.

A perennial stream is one that flows continuously, whereas an ephemeral stream is one that flows only in direct response to precipitation. These two classes are inadequate to describe all the varieties of streamflow, but most streams can be placed reasonably well into one class or the other. The correct classification is important because separate estimating equations have been developed for each class, and the mean discharge for an ephemeral stream will be greatly overestimated when its width and depth measurements are entered in the equation for the perennial stream. The classification of a stream in the foothill areas in Utah may be particularly difficult.

APPLICATION TO UNGAGED SITES IN UTAH

A test sample of depositional bar cross sections was collected at 57 gaging sites in Utah and Idaho. Three cross sections were measured at most sites. The average cross-section measurements were used to define equations that can be used to estimate streamflow characteristics in Utah. The reliability of each equation is indicated by the standard error of estimate, in percent.

Mean annual streamflow

The mean annual streamflow of ephemeral streams can be estimated through the use of equation (1). Equations (2) and (3) are used for perennial streams.

The equations for estimating mean annual streamflow are:

		Standard error (percent)
Ephemeral streams within Utah:		
(1)	$\underline{Qa} = 31\underline{W}^{1.30}$	73
Perennial streams within the Colorado River basin:		
(2)	$\underline{Qa} = 80\underline{W}^{1.79}$	34

Standard error (percent)

Perennial streams within the Great Basin:

(3) $\underline{Qa} = 50\underline{W}^{1.48}(\underline{D}+1)^{2.53}$ 34

The terms are:

$\underline{Qa}$ is the mean annual streamflow, in cubic feet per second.

$\underline{W}$ is the width of the channel bar cross section, in feet.

$\underline{D}$ is the average depth of the channel bar cross section, in feet, plus a constant value of 1.0.

The width of the channel bar cross section is significant in all the mean annual streamflow equations. Depth is significant only in equation (3), which applies to the Great Basin. The ephemeral relation has the smallest equation constant and width exponent of the group. The variance of the constants and exponents indicate the error that can result from an incorrect stream classification.

Use of the tables

The estimating equations for mean annual streamflow are given in tabular form (tables 1-3).

To find the mean annual streamflow for an ephemeral stream (table 1) with a width of 45 feet follow these steps:

1. Replace the right digit of the width with a zero. This changes 45 to 40.

2. Find this value, or row, under Width, the first column in table 1.

3. Now traverse the row to the right. Read the discharge under the digit column to the right of Width that was replaced by zero. Moving right along the "40" row, a value of 4,370 acre-feet per year is found under 5. For a width of 21 feet, the result would be 1,620 acre-feet per year.

Table 3 is a series of relations developed for depths ranging from 0.4 to 1.6 feet.

Floodflow characteristics

It was possible to relate the channel-geometry measurements to floodflow characteristics on the basis of the relation of the 10-year flood to mean annual streamflow. Three areas in the State were defined from information collected at 85 gaging stations. The locations of the sites used to define these three relations were then used to delineate areas (fig. 2) of similar streamflow characteristics. An analysis of information within each of these areas provided reliable estimating equations for both perennial and ephemeral

TABLE 1.--THE RELATION OF MEAN ANNUAL STREAMFLOW, IN ACRE-FEET, TO SECTION WIDTH, IN FEET, FOR EPHEMERAL STREAMS.

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	31	76	129	188	251	318	389	463	539
10	619	700	784	870	958	1050	1140	1230	1330	1420
20	1520	1620	1720	1830	1930	2040	2140	2250	2360	2470
30	2580	2690	2810	2920	3040	3150	3270	3390	3510	3630
40	3750	3870	4000	4120	4240	4370	4500	4620	4750	4880
50	5010	5140	5270	5410	5540	5670	5810	5940	6080	6220
60	6350	6490	6630	6770	6910	7050	7190	7330	7480	7620
70	7760	7910	8050	8200	8340	8490	8640	8790	8930	9080
80	9230	9380	9530	9690	9840	9990	10100	10300	10500	10600
90	10800	10900	11100	11200	11400	11500	11700	11900	12000	12200
100	12300	12500	12700	12800	13000	13100	13300	13500	13600	13800

THE STANDARD ERROR OF ESTIMATE IS 73 PERCENT.

TABLE 2.--THE RELATION OF MEAN ANNUAL STREAMFLOW, IN ACRE-FEET, TO SECTION WIDTH, IN FEET, FOR PERENNIAL STREAMS IN THE COLORADO RIVER BASIN.

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	80	277	572	957	1430	1980	2610	3310	4080
10	4930	5850	6840	7890	9010	10200	11400	12800	14100	15600
20	17100	18600	20200	21900	23600	25400	27300	29200	31200	33200
30	35200	37400	39600	41800	44100	46400	48900	51300	53800	56400
40	59000	61700	64400	67100	70000	72800	75800	78700	81800	84800
50	88000	91100	94300	97600	100900	104300	107700	111200	114700	118300
60	121900	125600	129300	133000	136800	140700	144600	148500	152500	156500
70	160600	164800	168900	173200	177400	181700	186100	190500	195000	199500
80	204000	208600	213200	217900	222600	227400	232200	237000	241900	246900
90	251900	256900	262000	267100	272300	277500	282700	288000	293300	298700
100	304200	309600	315100	320700	326300	331900	337600	343300	349100	354900

THE STANDARD ERROR OF ESTIMATE IS 34 PERCENT.

TABLE 3.--THE RELATION OF MEAN ANNUAL STREAMFLOW, IN ACRE FEET, TO SECTION WIDTH, IN FEET, FOR PERENNIAL STREAMS IN THE GREAT BASIN.

FOR A SECTION DEPTH OF 0.4 FEET

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	117	327	595	911	1270	1660	2090	2540	3030
10	3540	4070	4630	5220	5820	6450	7090	7760	8440	9150
20	9870	10600	11400	12100	12900	13700	14500	15400	16200	17100
30	18000	18900	19800	20700	21600	22600	23600	24500	25500	26500
40	27500	28500	29600	30600	31700	32800	33800	34900	36100	37200
50	38300	39400	40600	41700	42900	44100	45300	46500	47700	48900

FOR A SECTION DEPTH OF 0.8 FEET

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	221	617	1120	1720	2390	3140	3940	4800	5720
10	6680	7690	8750	9850	11000	12200	13400	14700	15900	17300
20	18600	20000	21500	22900	24400	25900	27500	29100	30700	32300
30	34000	35600	37400	39100	40900	42700	44500	46300	48200	50100
40	52000	53900	55900	57900	59900	61900	63900	66000	68100	70200
50	72300	74500	76600	78800	81000	83300	85500	87800	90100	92400

THE STANDARD ERROR OF ESTIMATE IS 34 PERCENT.

TABLE 3.--THE RELATION OF MEAN ANNUAL STREAMFLOW, IN ACRE FEET, TO SECTION WIDTH, IN FEET, FOR PERENNIAL STREAMS IN THE GREAT BASIN--CONTINUED

FOR A SECTION DEPTH OF 1.2 FEET

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	368	1030	1870	2860	3980	5210	6550	7980	9500
10	11100	12800	14500	16400	18300	20200	22300	24300	26500	28700
20	31000	33300	35700	38100	40600	43100	45700	48300	50900	53700
30	56400	59200	62100	65000	67900	70900	73900	77000	80100	83200
40	86400	89600	92800	96100	99500	102800	106200	109600	113100	116600
50	120200	123700	127300	131000	134700	138400	142100	145900	149700	153500

FOR A SECTION DEPTH OF 1.6 FEET

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	561	1560	2850	4360	6070	7950	9990	12200	14500
10	16900	19500	22200	25000	27900	30900	34000	37100	40400	43800
20	47200	50800	54400	58100	61900	65700	69700	73700	77700	81900
30	86100	90400	94700	99100	103600	108200	112800	117400	122200	126900
40	131800	136700	141700	146700	151800	156900	162100	167300	172600	178000
50	183400	188800	194300	199900	205500	211100	216900	222600	228400	234300

THE STANDARD ERROR OF ESTIMATE IS 34 PERCENT.

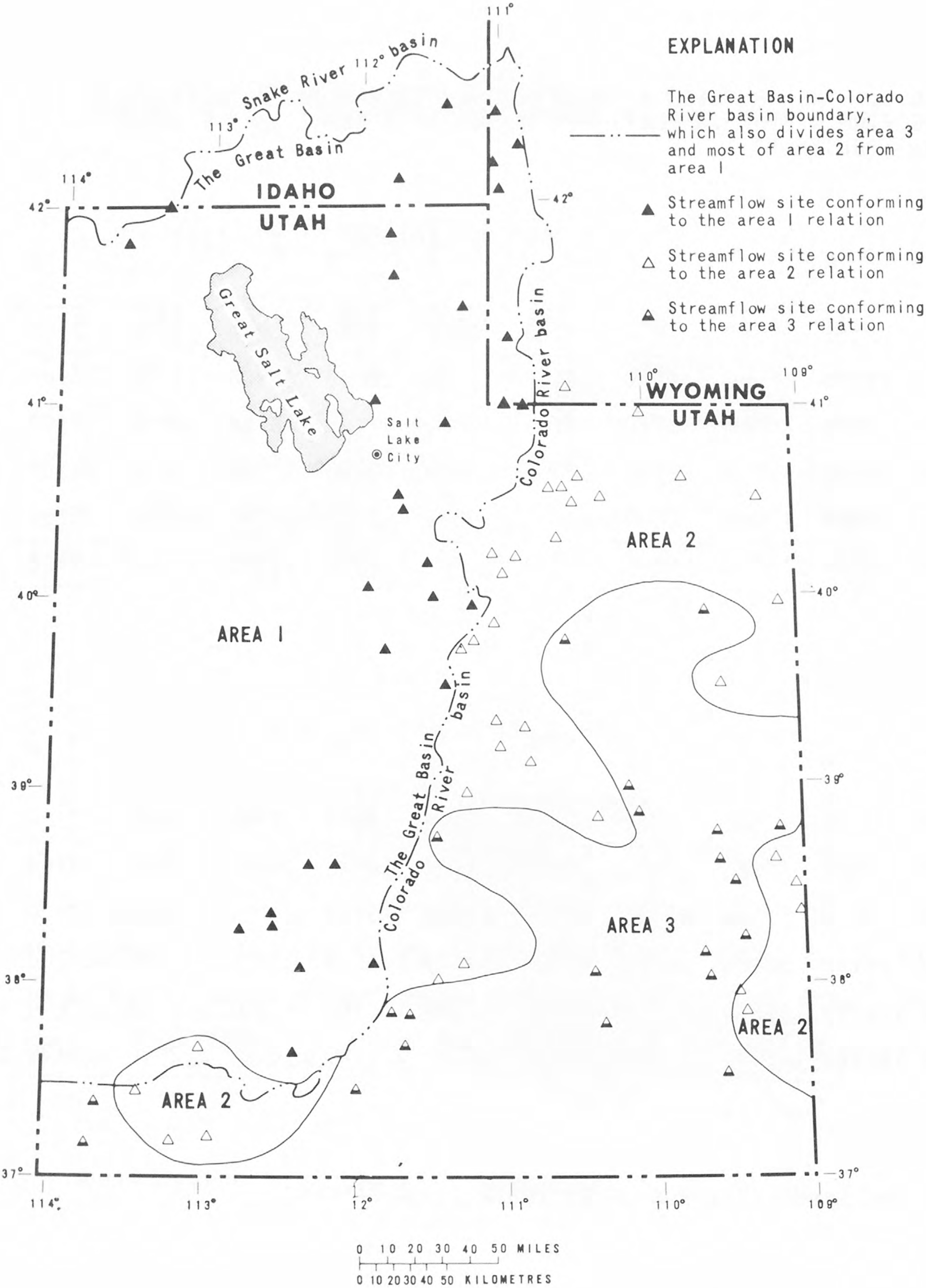

Figure 2.— Areas of Utah characterized by similar relationships between mean annual streamflow and the 10-year recurrence-interval flood.

streams, and estimates of floods with 25- and 50-year recurrence intervals can be made with equations (4)-(9):

The equations for estimating peak flood discharges for the 25- and 50-year recurrence-interval floods are:

		Standard error (percent)
Area 1:		
(4)	$\underline{P}_{25} = 21\underline{W}^{1.16}$	34
(5)	$\underline{P}_{50} = 25\underline{W}^{1.14}$	40
Area 2:		
(6)	$\underline{P}_{25} = 3.7\underline{W}^{1.57}$	28
(7)	$\underline{P}_{50} = 3.9\underline{W}^{1.58}$	33
Area 3:		
(8)	$\underline{P}_{25} = 215\underline{W}^{1.04}$	43
(9)	$\underline{P}_{50} = 585\underline{W}^{0.84}$	43

$\underline{P}_{25}$ is the 25-year recurrence-interval peak flood discharge, in cubic feet per second.

$\underline{P}_{50}$ is the 50-year recurrence-interval peak flood discharge, in cubic feet per second.

$\underline{W}$ is the width of the channel bar cross section, in feet.

Area 1 contains a sample of flood peaks derived from snowmelt and rainfall. Area 2 is a group of high-altitude perennial streams that generally experience snowmelt flood peaks. The area 3 sample generally experiences flooding as a result of thunderstorms. These samples appear to indicate that the equation constants are small for snowmelt derived flood peaks and large for thunderstorm derived flood peaks. The equation exponents show the opposite trend. These relations are shown in tabular form in tables 4-9.

The equations should be used only within the parameter ranges shown in table 10.

CONCLUSIONS

The use of the channel width and depth in estimating mean annual streamflow for perennial streams results in a standard error of estimate of 34 percent. Estimates of mean annual streamflow for ephemeral streams, however, have a standard error of estimate of 73 percent.

The relationships of the 10-year floodflow to mean annual streamflow delineate three areas of the State having similar runoff characteristics. Estimates of 25- and 50-year peak flood discharges, using the depositional bar channel width, in the three areas have standard errors of estimate ranging from 28 to 43 percent.

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TABLE 4.--THE RELATION OF THE 25-YEAR RECURRENCE-INTERVAL FLOOD, IN CUBIC FEET PER SECOND, TO SECTION WIDTH, IN FEET, FOR AREA 1.

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	21	47	75	105	136	168	201	234	269
10	304	339	375	412	448	486	524	562	600	639
20	678	718	758	798	838	879	920	961	1000	1040
30	1090	1130	1170	1210	1260	1300	1340	1380	1430	1470
40	1520	1560	1600	1650	1690	1740	1780	1830	1870	1920
50	1960	2010	2050	2100	2150	2190	2240	2290	2330	2380
60	2430	2470	2520	2570	2610	2660	2710	2760	2800	2850
70	2900	2950	3000	3050	3090	3140	3190	3240	3290	3340
80	3390	3440	3490	3530	3580	3630	3680	3730	3780	3830
90	3880	3930	3980	4030	4080	4130	4180	4240	4290	4340
100	4390	4440	4490	4540	4590	4640	4690	4750	4800	4850
110	4900	4950	5000	5060	5110	5160	5210	5260	5320	5370
120	5420	5470	5530	5580	5630	5680	5740	5790	5840	5900
130	5950	6000	6050	6110	6160	6210	6270	6320	6370	6430
140	6480	6540	6590	6640	6700	6750	6810	6860	6910	6970
150	7020	7080	7130	7190	7240	7290	7350	7400	7460	7510

THE STANDARD ERROR OF ESTIMATE IS 34 PERCENT.

TABLE 5.--THE RELATION OF THE 50-YEAR RECURRENCE-INTERVAL FLOOD, IN CUBIC FEET PER SECOND, TO SECTION WIDTH, IN FEET, FOR AREA 1.

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	25	55	87	121	157	193	230	268	306
10	345	385	425	465	506	548	590	632	674	717
20	761	804	848	892	936	981	1030	1070	1120	1160
30	1210	1250	1300	1350	1390	1440	1490	1530	1580	1630
40	1680	1720	1770	1820	1870	1920	1970	2010	2060	2110
50	2160	2210	2260	2310	2360	2410	2460	2510	2560	2610
60	2660	2710	2760	2810	2860	2920	2970	3020	3070	3120
70	3170	3220	3280	3330	3380	3430	3480	3540	3590	3640
80	3690	3750	3800	3850	3900	3960	4010	4060	4120	4170
90	4220	4280	4330	4390	4440	4490	4550	4600	4660	4710
100	4760	4820	4870	4930	4980	5040	5090	5150	5200	5260
110	5310	5370	5420	5480	5530	5590	5640	5700	5750	5810
120	5860	5920	5980	6030	6090	6140	6200	6260	6310	6370
130	6420	6480	6540	6590	6650	6710	6760	6820	6880	6930
140	6990	7050	7100	7160	7220	7280	7330	7390	7450	7510
150	7560	7620	7680	7740	7790	7850	7910	7970	8020	8080

THE STANDARD ERROR OF ESTIMATE IS 40 PERCENT.

TABLE 6.--THE RELATION OF THE 25-YEAR RECURRENCE-INTERVAL FLOOD, IN CUBIC FEET PER SECOND, TO SECTION WIDTH, IN FEET, FOR AREA 2.

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	4	11	21	33	46	62	79	97	117
10	137	160	183	208	233	260	288	316	346	377
20	408	441	474	508	543	579	616	654	692	731
30	771	812	854	896	939	983	1030	1070	1120	1160
40	1210	1260	1310	1360	1410	1460	1510	1560	1610	1670
50	1720	1770	1830	1890	1940	2000	2060	2110	2170	2230
60	2290	2350	2410	2470	2530	2600	2660	2720	2790	2850
70	2920	2980	3050	3120	3180	3250	3320	3390	3460	3530
80	3600	3670	3740	3810	3880	3960	4030	4100	4180	4250
90	4330	4400	4480	4560	4630	4710	4790	4870	4950	5030
100	5110	5190	5270	5350	5430	5510	5600	5680	5760	5850
110	5930	6020	6100	6190	6270	6360	6450	6540	6620	6710
120	6800	6890	6980	7070	7160	7250	7340	7430	7530	7620
130	7710	7800	7900	7990	8090	8180	8280	8370	8470	8570
140	8660	8760	8860	8960	9050	9150	9250	9350	9450	9550
150	9650	9750	9860	9960	10100	10200	10300	10400	10500	10600

THE STANDARD ERROR OF ESTIMATE IS 28 PERCENT.

TABLE 7.--THE RELATION OF THE 50-YEAR RECURRENCE-INTERVAL FLOOD, IN CUBIC FEET PER SECOND, TO SECTION WIDTH, IN FEET, FOR AREA 2.

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	4	12	22	35	50	66	84	104	126
10	148	172	198	224	252	281	312	343	375	409
20	443	479	515	553	591	631	671	712	754	797
30	841	886	932	978	1030	1070	1120	1170	1220	1270
40	1330	1380	1430	1490	1540	1600	1650	1710	1770	1830
50	1890	1950	2010	2070	2130	2190	2260	2320	2380	2450
60	2520	2580	2650	2720	2790	2850	2920	2990	3060	3140
70	3210	3280	3350	3430	3500	3580	3650	3730	3810	3880
80	3960	4040	4120	4200	4280	4360	4440	4520	4610	4690
90	4770	4860	4940	5030	5110	5200	5290	5370	5460	5550
100	5640	5730	5820	5910	6000	6090	6180	6270	6370	6460
110	6550	6650	6740	6840	6930	7030	7130	7220	7320	7420
120	7520	7620	7720	7820	7920	8020	8120	8220	8330	8430
130	8530	8640	8740	8850	8950	9060	9160	9270	9380	9480
140	9590	9700	9810	9920	10000	10100	10300	10400	10500	10600
150	10700	10800	10900	11000	11200	11300	11400	11500	11600	11700

THE STANDARD ERROR OF ESTIMATE IS 33 PERCENT.

TABLE 8.--THE RELATION OF THE 25-YEAR RECURRENCE-INTERVAL FLOOD, IN CUBIC FEET PER SECOND, TO SECTION WIDTH, IN FEET, FOR AREA 3.

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	215	442	674	909	1150	1390	1630	1870	2110
10	2360	2600	2850	3100	3350	3590	3840	4090	4340	4600
20	4850	5100	5350	5610	5860	6110	6370	6620	6880	7130
30	7390	7650	7900	8160	8420	8670	8930	9190	9450	9710
40	9970	10200	10500	10700	11000	11300	11500	11800	12000	12300
50	12600	12800	13100	13400	13600	13900	14100	14400	14700	14900
60	15200	15500	15700	16000	16300	16500	16800	17000	17300	17600
70	17800	18100	18400	18600	18900	19200	19400	19700	20000	20200
80	20500	20800	21000	21300	21600	21800	22100	22400	22600	22900
90	23200	23400	23700	24000	24200	24500	24800	25000	25300	25600
100	25800	26100	26400	26700	26900	27200	27500	27700	28000	28300

THE STANDARD ERROR OF ESTIMATE IS 43 PERCENT.

TABLE 9.--THE RELATION OF THE 50-YEAR RECURRENCE-INTERVAL FLOOD, IN CUBIC FEET PER SECOND, TO SECTION WIDTH, IN FEET, FOR AREA 3.

WIDTH	0	1	2	3	4	5	6	7	8	9
0	0	585	1050	1470	1870	2260	2640	3000	3360	3700
10	4050	4380	4720	5050	5370	5690	6010	6320	6630	6940
20	7240	7550	7850	8150	8440	8740	9030	9320	9610	9900
30	10200	10500	10800	11000	11300	11600	11900	12100	12400	12700
40	13000	13200	13500	13800	14000	14300	14600	14800	15100	15400
50	15600	15900	16200	16400	16700	16900	17200	17500	17700	18000
60	18200	18500	18700	19000	19200	19500	19800	20000	20300	20500
70	20800	21000	21200	21500	21700	22000	22200	22500	22700	23000
80	23200	23500	23700	23900	24200	24400	24700	24900	25100	25400
90	25600	25900	26100	26300	26600	26800	27100	27300	27500	27800
100	28000	28200	28500	28700	28900	29200	29400	29600	29900	30100

THE STANDARD ERROR OF ESTIMATE IS 43 PERCENT.

Table 10.--Parameter ranges for equations (1)-(9)

Equation	Dependent variable (acre-feet or cubic feet per second)	Width (feet)	Depth (feet)
(1)	232 to 21,800	7.0 to 101	-
(2)	3,110 to 508,900	8.5 to 171	-
(3)	1,140 to 105,800	6.4 to 49	0.25 to 1.71
(4)	214 to 7,780	14 to 155	-
(5)	236 to 1,990	14 to 49	-
(6)	82 to 7,780	8.2 to 171	-
(7)	88 to 8,600	8.5 to 171	-
(8)	1,170 to 25,900	12 to 102	-
(9)	2,390 to 33,400	12 to 102	-

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