Technique for Estimating Depth of Floods in Tennessee

Charles R. Gamble

U.S. GEOLOGICAL SURVEY
Water Resources Investigations 83-4050

Prepared in cooperation with the

TENNESSEE DEPARTMENT OF TRANSPORTATION

Nashville, Tennessee
1983

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES A. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U. S. Geological Survey
A-413 Federal Building
U.S. Courthouse
Nashville, Tennessee 37203

Copies of this report can
be purchased from:

Open-File Services Section
Western Services Section
U.S. Geological Survey
Box 25425, Federal Center
Lakewood, Colorado 80225
(Telephone: (303) 234-5888)

CONTENTS

ILLUSTRATIONS

TABLES

Conversion to Metric Units

The analysis and compilations in this report were made using inch-pound units of measurements. To convert inch-pound units to metric units, the following conversion factors should be used:

Multiply	By	To obtain
cubic feet per second (ft^3/s)	0.0283	cubic meters per second (m^3/s)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)

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

Technique for Estimating Depth of Floods in Tennessee

Charles R. Gamble

ABSTRACT

Estimates of flood depths are needed for the design of roadways across flood plains and for other types of construction along streams. Equations for estimating flood depths in Tennessee were derived using data for 150 gaging stations. The equations are based on drainage basin size and can be used to estimate depths of the 10-year and 100-year floods for four hydrologic areas. Estimates of depths of floods having recurrence intervals falling between 10 and 100 years can be made graphically. Standard errors range from 22 to 30 percent for the 10-year depth equations and from 23 to 30 percent for the 100-year depth equations.

INTRODUCTION

Population growth and economic expansion have resulted in increased use and development of land in and adjacent to flood plains. Knowledge of the flood characteristics of the streams involved is essential for wise use of these areas. If the approximate frequency and depth of flooding are known, adequate design and proper use of flood-prone areas can minimize flood damage.

At some sites it is not economically feasible to design structures for extreme floods such as the 50-year or the 100-year flood. This is especially true for some bridges and culverts at small streams on secondary roads where average daily traffic is low and where the duration of flood inundation of road embankments is short. Therefore, the Tennessee Department of Transportation sometimes designs bridges, culverts, and roadway embankments for floods as small as the 10-year flood. The 10-year flood is defined as the peak discharge which will be exceeded once, on the average, in 10 years, or stated another way, the peak discharge which has a 10 percent chance of being exceeded in any year. Techniques to estimate flood depths to aid in the design of roadway embankments and drainage structures have been developed by this study which was done in cooperation with the Tennessee Department of Transportation.

This study was concerned with developing techniques for estimating depths of floods for selected recurrence intervals of 10 to 100 years. Gamble and Lewis (1977) previously presented a technique for estimating the depth of the 100-year flood for unregulated streams in Tennessee. Depths of 100-year floods have been re-analyzed in this study so that consistent estimates of the 10-year and 100-year flood depths can be presented in the same report. Equations for estimating 100-year flood depths presented herein supersede those given by Gamble and Lewis (1977).

The purpose of this report is to present methods for estimating depths of various recurrence interval floods for unregulated streams in Tennessee. Relations between the size of the drainage basin and flood depths for four hydrologic areas of the state are defined.

DEFINITION OF FLOOD DEPTHS

Estimation of flood depth at a specific site on a stream and flood mapping probably are the major uses of the relations developed in this study.

For simplicity and ease of use, it was necessary to relate depth to some parameter which could be obtained without visiting the stream site. Because 7½-minute topographic maps are available for 100 percent of Tennessee, depth has been related to parameters which can be obtained from these maps. The assumption was made that the elevations represented on 7½-minute topographic maps by contour lines which cross stream channels approximate the elevation of the median discharge at the point of the crossing. The median discharge is that discharge which is exceeded 50 percent of the time. A study based on selected stations seems to substantiate this assumption. Aerial photographs used to prepare topographic maps are taken when vegetation is dormant. It is at this time when streamflow approaches median discharge in most Tennessee streams. Depth of floods used in this report is the depth above the stream contour crossings shown on 7½-minute topographic maps.

The median discharge, the 10-year and 100-year flood discharges, and their corresponding stages were determined for each gaging station used in the analysis. Median discharges are from Gold (1981). The 10-year and 100-year flood discharges used are the weighted discharges from table 2 of Randolph and Gamble (1976). For crest-stage partial-record stations and stations having short periods of record, the median discharge and stage were estimated on the basis of discharge measurements, slope of the rating curve, size of the drainage basin, and knowledge of the site. As used in this report, the difference between the 10-year flood stage and the median discharge stage is the depth of the 10-year flood, and the difference between the 100-year flood stage and the median discharge stage is the depth of the 100-year flood. The data used in the analyses are shown in table 1.

Table 1.--Data used in the analyses

Station number	Station name	Hydrologic area	Drainage area (mi²)	Median stage (ft)	Median discharge (ft³/s)	100-year flood Stage (ft)	100-year flood Discharge (ft³/s)	Depth of 100-year flood (ft)	10-year flood Stage (ft)	10-year flood Discharge (ft³/s)	Depth of 10-year flood (ft)
02384900	Coahulla Creek near Cleveland	1	4.35	0.9	-	8.5	2,750	7.6	7.5	1,420	6.6
03313600	West Fork Drakes Creek tributary near Fountain Head	3	.95	1.9	-	12.8	928	10.9	8.9	482	7.0
03409500	Clear Fork near Robbins	2	272	2.1	142	20.5	44,600	18.4	16.5	26,100	14.4
03415000	West Fork Obey River near Alpine	2	81	1.7	49.0	19.0	19,800	17.3	15.4	12,100	13.7
03415700	Big Eagle Creek near Livingston	2	4.77	1.0	-	13.5	2,440	12.5	7.7	1,380	6.7
03416000	Wolf River near Byrdstown	2	106	1.7	67.7	12.5	31,400	10.8	9.8	16,700	8.1
03417700	Mathews Branch tributary near Livingston	2	.49	.2	-	10.5	687	10.3	6.2	333	6.0
03418000	Roaring River near Hilham	2	51.4	1.3	42.0	15.0	12,800	13.7	10.8	7,120	9.5
03418900	Raccoon Creek near Old Winesap	2	1.52	3.2	-	11.7	667	8.5	10.8	376	7.6
03420360	Mud Creek tributary Number 2 near Summitville	3	2.28	1.5	-	5.5	1,440	4.0	5.2	764	3.7
03420380	Mud Creek tributary near Summitville	3	1.03	2.0	-	7.0	790	5.0	6.3	455	4.3
03420400	Mud Creek near Summitville	3	7.30	.6	-	6.4	3,780	5.8	5.4	2,020	4.8
03420500	Barren Fork near Trousdale	3	126	1.4	97.6	18.1	38,300	16.7	14.3	20,000	12.9
03420600	Owen Branch near Centertown	3	4.60	1.0	-	8.4	3,690	7.4	5.4	1,580	4.4
03421100	Sink tributary at McMinnville	3	.47	.2	-	8.4	549	8.2	5.6	322	5.4
03425500	Spring Creek near Lebanon	3	35.3	1.0	13.5	12.2	13,300	11.2	10.4	8,520	9.4
03425700	Spencer Creek near Lebanon	3	3.32	.5	-	9.7	3,800	9.2	8.1	1,950	7.6
03425800	Cedar Creek tributary at Green Hill	3	.86	1.0	-	9.2	817	8.2	6.2	410	5.2
03426000	Drakes Creek above Hendersonville	3	19.2	1.0	5.3	14.0	8,760	13.0	10.6	5,130	9.6
03426800	East Fork Stones River at Woodbury	3	39.1	2.5	28.3	17.5	16,400	15.0	15.4	9,230	12.9
03427830	Short Creek tributary near Christiana	3	.17	2.2	-	10.2	250	8.0	7.6	139	5.4
03427840	Short Creek near Christiana	3	3.54	3.1	-	9.3	4,020	6.2	9.0	2,510	5.9
03428000	West Fork Stones River near Murfreesboro	3	122	1.9	48.6	22.5	39,000	20.6	20.6	23,200	18.7
03430400	Mill Creek at Nolensville	3	12.0	1.9	-	10.5	9,130	8.6	8.0	6,030	6.1
03430600	Mill Creek at Hobson Pike	3	43.0	.5	-	14.6	14,500	14.1	13.6	9,090	13.1
03430700	Indian Creek at Pettus Road at Nashville	3	3.86	0	-	9.3	2,500	9.3	6.9	1,530	6.9
03431000	Mill Creek near Antioch	3	64.0	2.9	22.1	21.5	21,600	18.6	18.1	13,100	15.2
03431080	Sims Branch at Elm Hill Pike, near Donelson	3	3.92	1.3	-	15.5	3,180	14.2	11.0	1,730	9.7
03431120	West Fork Browns Creek at General Bates Drive at Nashville	3	3.30	1.2	-	8.5	3,660	7.3	7.0	2,170	5.8
03431240	East Fork Browns Creek at Baird-Ward Printing Company at Nashville	3	1.58	.2	-	5.6	899	5.4	4.6	493	4.4
03431340	Browns Creek at Factory Street at Nashville	3	13.2	1.9	-	9.8	5,670	7.9	8.6	3,420	6.7
03431520	Claylick Creek at Lickton	3	4.13	1.3	-	9.2	3,420	7.9	7.1	1,880	5.8
03431580	Ewing Creek at Knight Road near Bordeaux	3	13.3	1.0	-	11.0	7,540	10.0	10.4	4,970	9.4
03431600	Whites Creek at TuckerRoad near Bordeaux	3	51.6	3.7	21.8	19.5	19,200	15.8	17.0	11,900	13.3
03431630	Richland Creek at Lynnwood Blvd., at Belle Meade	3	2.21	1.3	-	5.0	1,710	3.7	4.3	1,010	3.0
03431650	Vaughns Gap Branch at Percy Warner Blvd., Belle Meade	3	2.66	1.7	-	8.0	2,250	6.3	6.9	1,270	5.2

Table 1.--Data used in the analyses--Continued

Station number	Station name	Hydro-logic area	Drainage area (mi²)	Median stage (ft)	Median discharge (ft³/s)	100-year flood Stage (ft)	100-year flood Discharge (ft³/s)	Depth of 100-year flood (ft)	10-year flood Stage (ft)	10-year flood Discharge (ft³/s)	Depth of 10-year flood (ft)
03431700	Richland Creek at Charlotte Ave., at Nashville	3	24.3	1.2	9.0	16.5	10,600	15.3	12.4	6,350	11.2
03431800	Sycamore Creek near Ashland City	3	97.2	2.7	47.5	14.5	23,000	11.8	12.4	12,600	9.7
03432500	West Harpeth River near Leipers Fork	3	66.9	1.0	21.5	16.0	38,900	15.0	14.7	17,600	13.7
03433500	Harpeth River at Bellevue	3	393	1.8	167	24.5	41,400	22.7	21.2	23,800	19.4
03434500	Harpeth River near Kingston Springs	3	666	2.1	309	34.0	69,700	31.9	28.1	40,900	26.0
03435020	Red River near New Deal	3	9.32	3.2	-	11.5	5,820	8.3	10.1	3,510	6.9
03435030	Red River near Portland	3	15.1	2.7	10.7	14.0	6,990	11.3	11.9	4,230	9.2
03435600	Mill Branch near White House	3	3.5	1.4	-	9.1	2,430	7.7	6.8	1,330	5.4
03436000	Sulphur Fork Red River near Adams	3	165	4.1	73.0	28.5	27,200	24.4	22.8	14,800	18.7
03436700	Yellow Creek near Shiloh	3	124	4.2	79.3	17.0	17,900	12.8	15.5	10,600	11.3
03461200	Cosby Creek above Cosby	1	10.2	.9	23.0	4.9	2,580	4.0	3.9	1,510	3.0
03467000	Lick Creek at Mohawk	1	220	2.8	81.2	18.0	16,800	15.2	16.8	9,950	14.0
03469110	Ramsey Creek near Pittman Center	1	2.18	3.2	-	6.8	641	3.6	5.9	311	2.7
03469130	Little Pigeon River near Sevierville	1	110	1.5	-	19.5	19,400	18.0	16.2	13,700	14.7
03469500	West Prong Little Pigeon River near Pigeon Forge	1	76.2	1.5	-	14.2	13,800	12.7	12.0	9,010	10.5
03470000	Little Pigon River at Sevierville	1	353	1.8	339	16.0	50,500	14.2	12.0	29,000	10.2
03480000	Watauga River at Stump Knob	1	172	1.7	198	21.2	36,300	19.5	12.7	16,600	11.0
03482500	Roan Creek at Butler	1	166	.8	97.6	11.4	11,100	10.6	8.0	5,450	7.2
03483000	Watauga River at Butler	1	427	1.5	455	18.1	37,600	16.6	12.6	20,500	11.1
03485500	Doe River at Elizabethton	1	137	1.1	163	8.8	11,700	7.7	6.6	6,320	5.5
03491000	Big Creek near Rogersville	1	47.3	1.9	24.6	9.8	6,350	7.9	7.8	4,110	5.9
03491200	Big Creek tributary near Rogersville	1	2.00	.8	-	8.1	1,070	7.3	7.1	469	6.3
03497300	Little River above Townsend	1	106	2.1	208	16.5	26,200	14.4	11.8	14,600	9.7
03498000	Little River near Walland	1	192	1.7	222	19.5	26,600	17.8	13.5	15,200	11.8
03498500	Little River near Maryville	1	269	7.1	312	25.5	37,200	18.4	21.9	22,900	14.8
03498700	Nails Creek near Knoxville	1	.36	1.5	-	6.5	246	5.0	4.7	136	3.2
03518500	Tellico River at Tellico Plains	1	118	1.8	188	14.5	20,900	12.7	12.3	13,000	10.5
03519600	Island Creek at Vonore	1	11.2	2.8	-	12.5	2,790	9.7	11.0	1,470	8.2
03519610	Baker Creek tributary near Binfield	1	2.10	2.7	-	7.2	1,060	4.5	6.4	455	3.7
03519630	Griffitts Branch near Greenback	1	1.46	1.8	-	9.8	817	8.0	7.4	333	5.6
03519640	Baker Creek near Greenback	1	16.0	2.5	23	10.1	3,790	7.6	8.7	1,940	6.2
03519700	Bat Creek near Vonore	1	30.7	1.5	-	17.7	6,170	16.2	13.2	3,290	11.7
03520100	Sweetwater Creek near Loudon	1	62.2	2.5	-	14.6	5,760	12.1	11.4	3,180	8.9
03534000	Coal Creek at Lake City	1	24.5	0	-	10.6	7,760	10.6	7.5	4,790	7.5
03534500	Buffalo Creek at Norris	1	7.82	1.4	-	11.4	2,070	10.0	9.4	1,230	8.0
03535000	Bullrun Creek near Halls Crossroads	1	68.5	2.4	42.5	12.0	13,800	9.6	10.7	7,310	8.3
03535160	Beaver Creek near Halls Crossroads	1	14.1	1.0	-	10.4	4,160	9.4	9.2	2,320	8.2
03535180	Willow Fork near Halls Crossroads	1	3.23	2.5	-	9.5	1,490	7.0	7.6	706	5.1
03538130	Caney Creek near Kingston	1	5.55	2.8	-	8.3	2,420	5.5	7.4	1,580	4.6

Table 1.--Data used in the analyses--Continued

Station number	Station name	Hydro-logic area	Drainage area (mi²)	Median stage (ft)	Median discharge (ft³/s)	100-year flood Stage (ft)	100-year flood Discharge (ft³/s)	Depth of 100-year flood (ft)	10-year flood Stage (ft)	10-year flood Discharge (ft³/s)	Depth of 10-year flood (ft)
03538200	Poplar Creek near Oliver Springs	2	55.9	1.9	-	21.1	9,990	19.2	17.7	6,110	15.8
03538250	East Fork Poplar Creek near Oak Ridge	2	19.5	2.0	32.2	16.0	4,340	14.0	13.1	2,740	11.1
03538300	Rock Creek near Sunbright	2	5.54	.2	-	6.6	1,880	6.4	5.7	1,210	5.5
03538600	Obed River at Crossville	2	12.0	1.0	-	10.6	1,830	9.6	9.5	1,140	8.5
03538900	Self Creek near Big Lick	2	3.80	1.9	-	10.1	1,380	8.2	7.2	748	5.3
03539100	Byrd Creek near Crossville	2	1.10	2.8	-	11.4	494	8.6	10.8	241	8.0
03539500	Daddys Creek near Crab Orchard	2	93.5	1.5	54.1	26.0	15,500	24.5	18.6	8,950	17.1
03541100	Bitter Creek near Camp Austin	2	5.53	2.0	-	9.5	4,310	7.5	7.4	2,270	5.4
03541200	Forked Creek near Oakdale	2	2.44	4.0	-	10.3	1,400	6.3	8.1	733	4.1
03541500	Whites Creek near Glen Alice	2	108	1.9	55.1	24.4	42,800	22.5	19.8	22,700	17.9
03543500	Sewee Creek near Decatur	2	117	.5	75.7	23.0	20,100	22.5	18.5	11,200	18.0
03544500	Richland Creek near Dayton	1	50.2	1.0	-	11.7	14,900	10.7	9.6	8,390	8.6
03556000	Turtletown Creek at Turtletown	1	26.9	1.3	42.2	7.8	1,900	6.5	6.5	1,150	5.2
03565300	South Chestuee Creek near Benton	1	31.8	1.1	19.2	12.0	9,050	10.9	9.5	5,060	8.4
03565500	Oostanaula Creek near Sanford	1	57.0	2.8	58.1	13.5	8,190	10.7	10.5	4,030	7.7
03566200	Brymer Creek near McDonald	1	9.68	1.8	-	8.0	2,470	6.2	7.0	1,530	5.2
03566420	Wolftever Creek near Ooltewah	1	18.8	.8	13.4	9.5	5,590	8.7	8.3	3,350	7.5
03567500	South Chickamauga Creek near Chickamauga	1	428	2.2	296	23.0	35,100	20.8	19.0	22,500	16.8
03570800	Little Brush Creek near Dunlap	1	15.4	2.0	-	11.3	3,910	9.3	9.0	2,750	7.0
03571000	Sequatchie River near Whitwell	1	384	2.6	328	17.5	32,500	14.9	16.0	20,100	13.4
03571600	Brown Spring Branch near Sequatchie	1	0.67	1.2	-	8.7	285	7.5	7.0	176	5.8
03571800	Battle Creek near Monteagle	1	50.4	.2	-	11.7	9,130	11.5	10.1	6,150	9.9
03574700	Big Huckleberry Creek near Belvidere	3	2.18	.5	-	9.5	1,770	9.0	6.6	897	6.1
03578000	Elk River near Pelham	3	65.6	3.3	53.2	14.0	12,100	10.7	12.6	7,440	9.3
03578500	Bradley Creek near Prairie Plains	3	41.3	1.5	23.5	16.0	8,290	14.5	13.4	4,790	11.9
03581500	West Fork Mulberry Creek at Mulberry	3	41.2	1.5	-	16.0	16,400	14.5	14.2	10,900	12.7
03582300	Norris Creek near Fayetteville	3	42.6	.5	-	12.8	17,800	12.3	11.4	10,700	10.9
03583000	Bradshaw Creek at Frankewing	3	36.5	1.5	17.2	16.9	14,400	15.4	15.1	8,790	13.6
03583200	Chicken Creek at McBurg	3	7.66	.2	-	8.3	6,600	8.1	6.9	4,120	6.7
03583300	Richland Creek near Cornersville	3	47.5	2.5	18.3	18.2	18,100	15.7	16.0	10,500	13.5
03584000	Richland Creek near Pulaski	3	366	1.5	195	29.5	90,200	28.0	23.0	42,500	21.5
03587200	Bluewater Creek tributary near Leoma	3	.49	.8	-	6.8	436	6.0	5.0	261	4.2
03587500	Shoal Creek above Little Shoal Creek at Lawrenceburg	3	27.0	1.0	-	19.5	12,600	18.5	13.6	6,620	12.6
03588400	Chisholm Creek at Westpoint	3	43.0	3.1	37.7	14.5	16,100	11.4	11.9	8,000	8.8
03588500	Shoal Creek at Iron City	3	348	3.0	293	27.0	90,200	24.0	22.4	41,700	19.4
03594200	Eagle Creek near Clifton Junction	4	19.0	0	-	8.5	10,700	8.5	7.2	4,690	7.2
03596000	Duck River below Manchester	3	107	.9	60.2	22.0	44,600	21.1	17.3	19,500	16.4
03597000	Garrison Fork at Fairfield	3	66.3	1.5	32.7	24.6	28,100	23.1	19.6	15,800	18.1
03597300	Wartrace Creek above Bell Buckle	3	4.99	2.4	-	16.0	4,690	13.6	11.5	2,670	9.1
03597400	Wartrace Creek near Bell Buckle	3	9.59	.4	-	10.3	7,410	9.9	9.2	4,490	8.8
03597450	Kelly Creek tributary near Bell Buckle	3	.73	.3	-	4.9	684	4.6	4.7	498	4.4
03597500	Wartrace Creek at Bell Buckle	3	16.3	2.5	6.5	12.0	10,200	9.5	10.5	6,490	8.0

Table 1.--Data used in the analyses--Continued

Station number	Station name	Hydrologic area	Drainage area (mi^2)	Median stage (ft)	Median discharge (ft^3/s)	100-year flood		Depth of 100-year flood (ft)	10-year flood		Depth of 10-year flood (ft)
						Stage (ft)	Discharge (ft^3/s)		Stage (ft)	Discharge (ft^3/s)	
03597550	Muse Branch near Bell Buckle	3	1.86	1.9	-	6.1	1,390	4.2	5.2	867	3.3
03598200	Weakley Creek near Rover	3	9.46	0	-	6.2	5,030	6.2	5.6	2,550	5.6
03599200	East Rock Creek at Farmington	3	43.1	.5	-	17.5	20,000	17.0	14.3	10,700	13.8
03599400	Little Flat Creek tributary near Rally Hill	3	.63	.5	-	8.6	701	8.1	6.1	384	5.6
03600500	Big Bigby Creek at Sandy Hook	3	17.5	1.5	10.9	13.0	10,600	11.5	10.4	5,510	8.9
03602500	Piney River at Vernon	3	202	2.7	141	23.5	43,400	20.8	18.4	22,700	15.7
03604070	Coon Creek tributary near Hohenwald	3	.51	1.8	-	6.7	345	4.9	4.9	158	3.1
03604080	Hugh Hollow Branch near Hohenwald	3	1.52	.5	-	4.2	968	3.7	3.8	482	3.3
03604090	Coon Creek above Chop Hollow near Hohenwald	3	6.02	1.5	-	7.2	3,660	5.7	5.8	1,770	4.3
03604100	Coon Creek near Hohenwald	3	10.1	1.5	6.1	8.3	4,840	6.8	6.9	2,580	5.4
03606500	Big Sandy River at Brucetown	4	205	3.5	117	16.5	18,900	13.0	15.5	10,800	12.0
07024300	Beaver Creek at Huntingdon	4	55.5	2.2	43	14.0	8,650	11.8	12.9	5,560	10.7
07025000	Rutherford Fork Obion River near Bradford	4	201	3.8	55.1	22.6	13,100	18.8	20.3	8,510	16.5
07025500	North Fork Obion River near Union City	4	480	2.0	185	21.0	40,800	19.0	20.2	22,300	18.2
07026500	Reelfoot Creek near Samburg	4	110	7.6	8.9	17.5	17,900	9.9	16.1	11,100	8.5
07027500	South Fork Forked Deer River at Jackson	4	495	5.7	267	22.8	35,300	17.1	20.5	18,900	14.8
07027800	South Fork Forked Deer River near Gates	4	932	7.0	(450)	21.3	42,400	14.3	20.1	24,600	13.1
07028500	North Fork Forked Deer River at Trenton	4	73.5	4.1	20.8	15.2	10,600	11.1	14.5	6,680	10.4
07028560	Cain Creek near Fruitland	4	6.17	.5	-	13.5	2,780	13.0	12.3	1,810	11.8
07028600	Cain Creek tributary near Trenton	4	.95	1.0	-	10.5	977	9.5	8.6	714	7.6
07028700	Cain Creek near Trenton	4	14.4	0	-	13.1	5,180	13.1	11.9	3,110	11.9
07028900	Middle Fork Forked Deer River near Spring Creek	4	88.2	0	-	12.5	17,100	12.5	11.2	8,630	11.2
07028935	Turkey Creek tributary near Medina	4	1.08	12.0	-	21.9	1,540	9.9	16.8	936	4.8
07028950	Turkey Creek at Fairview	4	13.3	2.5	-	15.9	8,590	13.4	15.1	5,590	12.6
07029050	Nash Creek near Tigrett	4	7.23	1.0	-	11.8	2,470	10.8	10.7	1,690	9.7
07029100	North Fork Forked Deer River at Dyersburg	4	939	5.0	482	29.5	34,400	24.5	27.7	21,400	22.7
07029370	Cypress Creek at Selmer	4	44.1	.5	-	16.0	5,630	15.5	13.4	3,620	12.9
07029400	Hatchie River at Pocahontas	4	837	10.0	473	34.1	49,800	24.1	30.0	29,200	20.0
07030240	Loosahatchie River near Arlington	4	262	4.0	110	25.0	24,000	21.0	23.3	14,300	19.3
07030280	Loosahatchie River at Brunswick	4	505	6.3	135	26.4	47,100	20.1	24.0	28,700	17.7
07031650	Wolf River near Germantown	4	699	4.7	491	30.0	42,100	25.3	25.0	24,500	20.3
07031700	Wolf River at Raleigh	4	771	-2.5	405	21.9	46,600	24.4	15.9	26,300	18.4
07032200	Nonconnah Creek near Germantown	4	68.2	5.3	4.5	29.4	11,050	24.1	22.2	6,800	16.9

METHOD OF ANALYSIS

Randolph and Gamble (1976) defined equations relating flood discharge characteristics to the size of drainage basin. Other basin characteristics such as stream length, stream slope, and mean basin elevation were also investigated to see if they improved the equations. The definition and method of computation of these characteristics are described by May and others (1970). The same characteristics were tested by multiple regression techniques in this analysis to determine whether their use would provide improved estimates of flood depth over the use of drainage basin size alone.

Gamble and Lewis (1977) defined a relation between depth of the 100-year flood and drainage area in four hydrologic areas of Tennessee. Those hydrologic areas, modified slightly, are used in this study.

The stations within each of the four hydrologic areas (fig. 1) were grouped together. For each area the 10-year flood depth was regressed on the four basin characteristics discussed previously. No significant decrease in reliability of the estimating equation was noted, as measured by the standard error of estimate, when all basin variables except size of the drainage basin were deleted. This one-variable equation is the most practical for estimating purposes because of its simplicity of use, and because additional variables showed little statistical improvement.

The first several regression analyses for the 10-year flood depths included 161 continuous-record gaging stations divided into four hydrologic areas. Those analyses resulted in equations that underestimate depths at sites with actual flood depths of 15 feet or more, and overestimate depths at sites with actual flood depths of 5 feet or less. Additional regression analyses were performed in an attempt to derive equations that would provide estimates of flood depths without bias. In those analyses hydrologic area

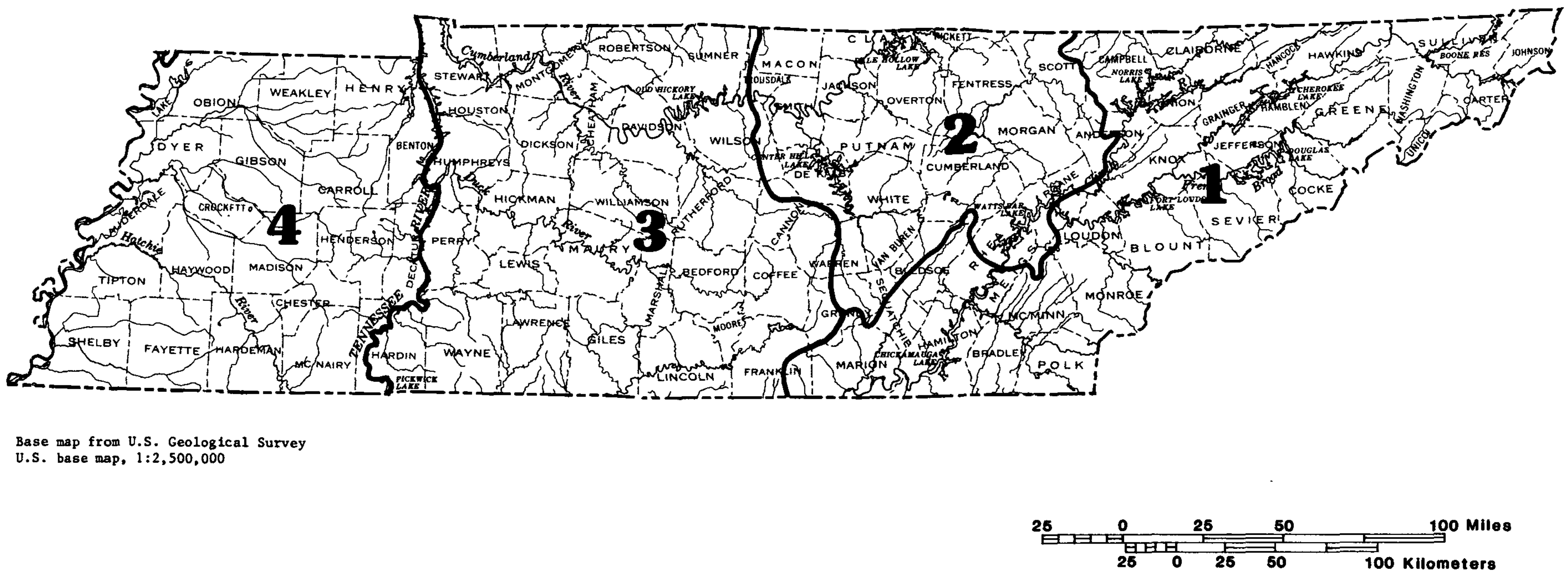

Figure 1.--Hydrologic areas for estimating flood depths in Tennessee.

boundaries were shifted, areas were combined, and the analyses were performed on data for the entire State without subdivision into hydrologic areas in an attempt to eliminate the bias. Although the standard errors of the regressions changed considerably with subsequent analyses, the amount of bias remained about the same for depths of about 15 feet or more.

Based on graphical plots of observed flood depths versus estimated depths, and station residuals versus observed depths, it appeared that most of the bias was caused by 11 stations randomly dispersed across the State. Examination of the data indicated that two stations in west Tennessee had flood depths of about one-half the depths that would be expected for that area. The two stations are 50 to 100 feet downstream from highway fills which cause considerable constriction of the flood flow and probably several feet of back water upstream from the highway. Consequently, a large part of the flood water is stored behind the fill which reduces considerably the amount and depth of flood flow at the station. Those two stations were deleted from subsequent regression analyses. However, problems of overestimating flood depths probably exist at similar sites in west Tennessee, and caution should be used in estimating flood depths for those sites.

Nine stations in central and east Tennessee were also deleted from subsequent regression analyses. Those stations are on streams with very narrow V-shaped valleys without a flood plain, or with a near vertical bedrock outcrop at one edge of the stream and a fairly steep slope at the other edge. In either case, the equations underestimate flood depths at those stations. Problems of underestimating flood depths probably exist at similar sites in central and east Tennessee, and caution should be used in estimating flood depths for those sites.

Deletion of the 11 stations across the State reduced the standard error of regression and reduced the bias. For the 10-year flood depths, the average of standard errors of all four hydrologic areas was about 33 percent using 161 stations, and about 26.5 percent using 150 stations. For the 100-year flood depths, the average error of all four hydrologic areas was about 32.5 percent using 161 stations, and about 27.8 percent using 150 stations. Although the bias in each equation was reduced considerably, the equations still have a tendency to underestimate the larger depths.

As a test, the depths of the 25-year and 50-year floods were computed for a few stations in each hydrologic area. The stations used were those with the lowest residuals for the 10-year flood. These depths and those for 10 and 100-year floods were plotted on normal probability paper. For most of these stations, the 25-year and the 50-year flood depths plotted very close to the straight line connecting the 10 and 100-year depths, indicating that depths for frequencies between the 10-year and the 100-year floods can be interpolated with reasonable accuracy.

Depths of the 10-year and the 100-year floods were then computed from the regression equations for drainage areas of 1 and 100 square miles for each hydrologic area (fig. 2). Depths of the 25-year and the 50-year floods were taken from the straight lines connecting the 10 and 100-year depths and are shown in figures 3 to 6.

The equations that were developed to compute depth of the 10-year and 100-year floods in each of the four hydrologic areas are given in table 2 and shown in graphical form on figures 3 to 6.

Table 2.--Summary of regression equations

[D, Depth of flood, in feet; A, Drainage basin size, in square miles]

Hydrologic area	Number of stations	10-year flood: Depth (ft)	10-year flood: Standard error of estimate (percent)	100-year flood: Depth (ft)	100-year flood: Standard error of estimate (percent)
1	41	$D = 4.11 (A)^{0.184}$	28	$D = 5.32 (A)^{0.186}$	28
2	18	$D = 5.33 (A)^{0.197}$	30	$D = 7.43 (A)^{0.181}$	29
3	68	$D = 4.45 (A)^{0.246}$	26	$D = 5.91 (A)^{0.224}$	30
4	23	$D = 6.98 (A)^{0.142}$	22	$D = 9.24 (A)^{0.116}$	23

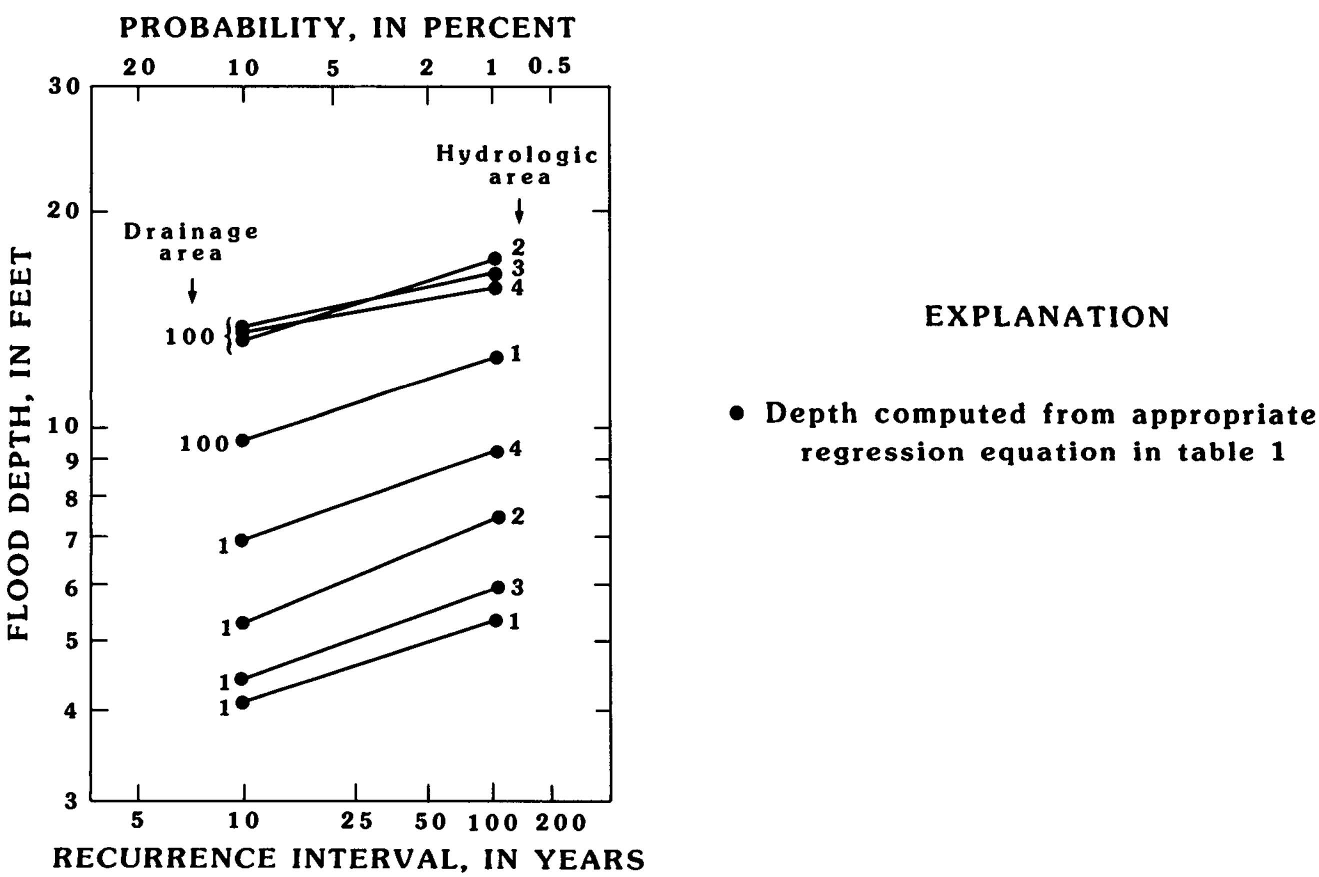

Figure 2.--Depth-frequency relation for 1 and 100 square miles in hydrologic areas 1-4.

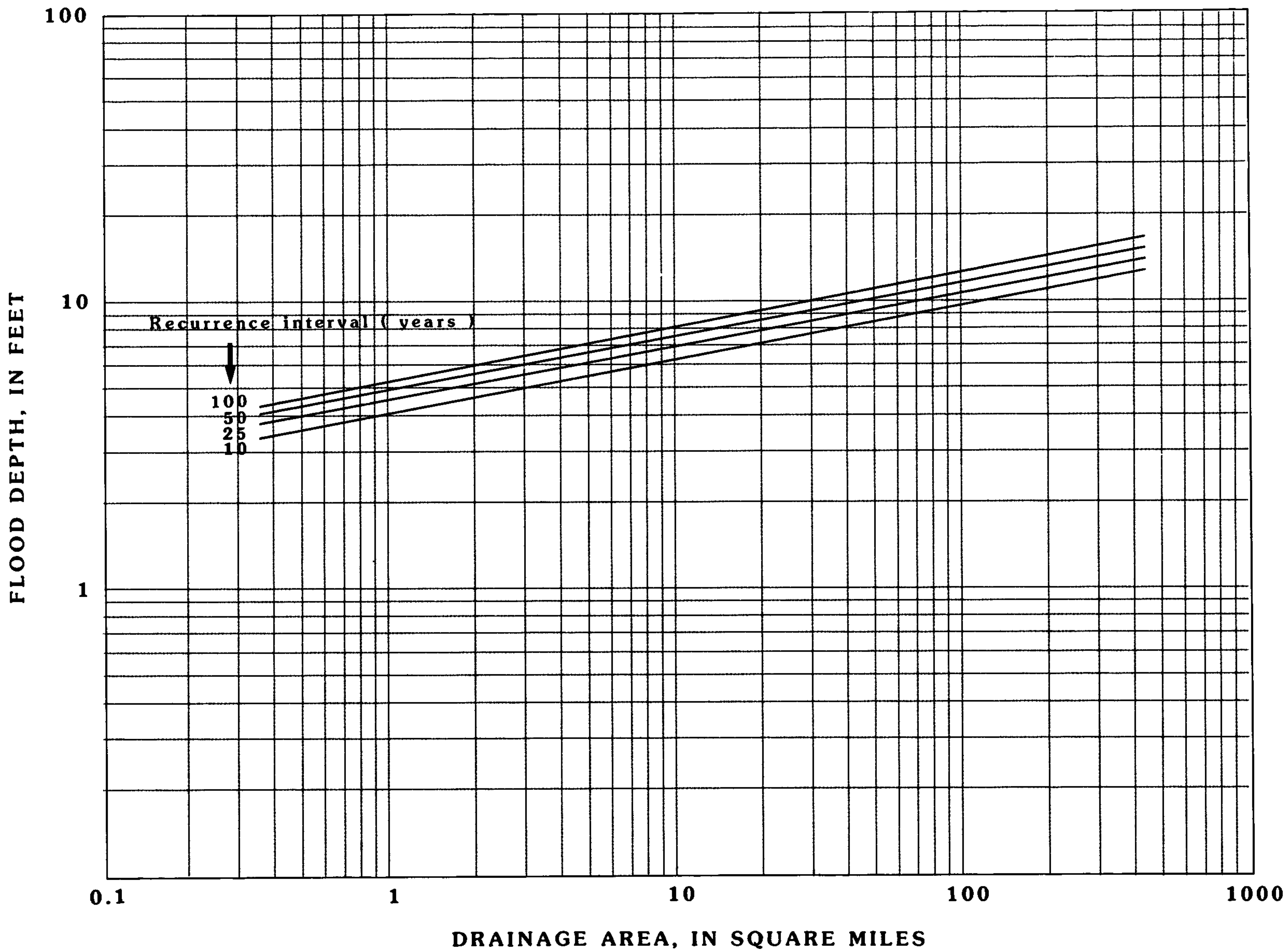

Figure 3.--Relation of flood depth to drainage area for hydrologic area 1.

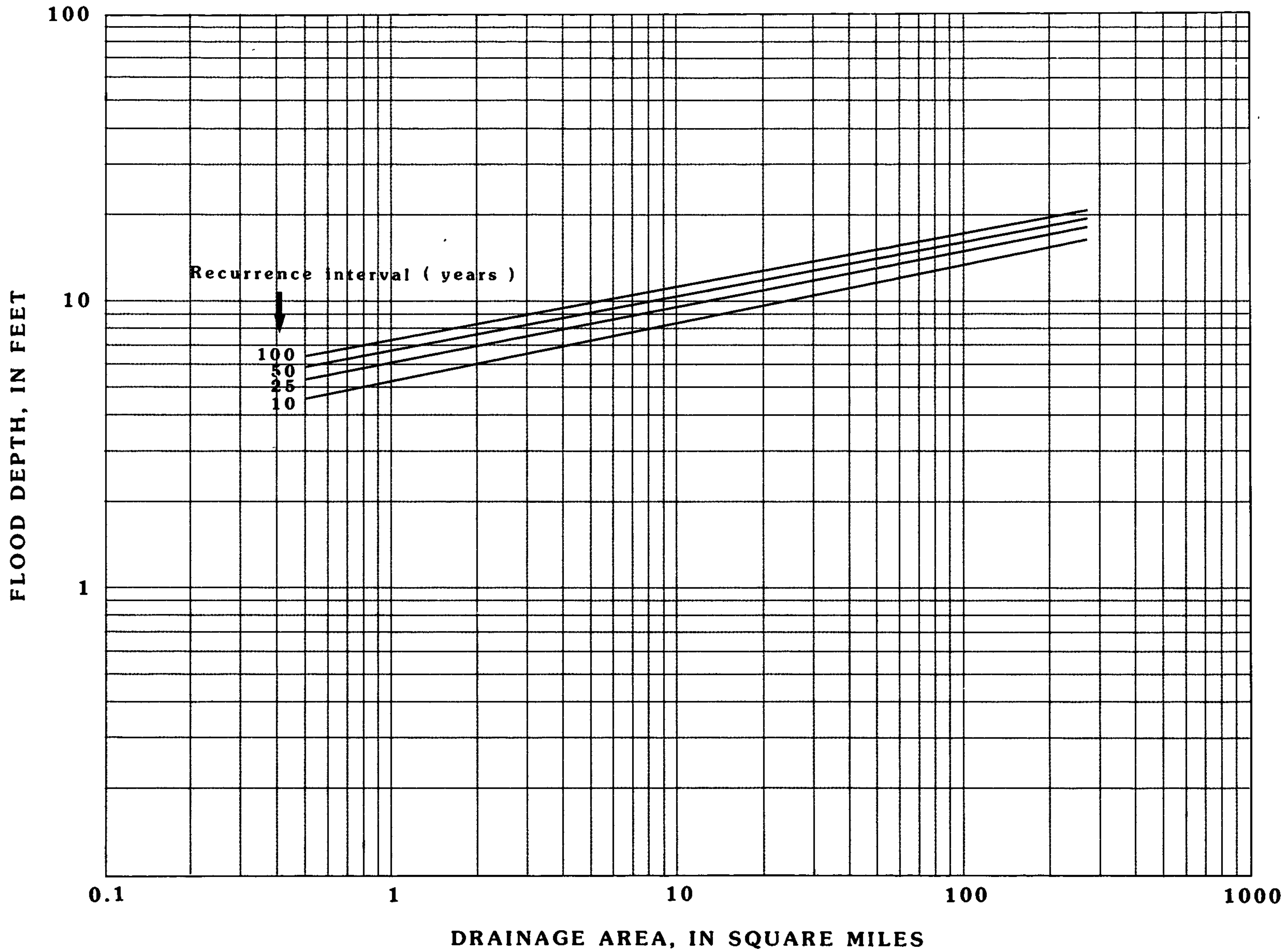

Figure 4.--Relation of flood depth to drainage area for hydrologic area 2.

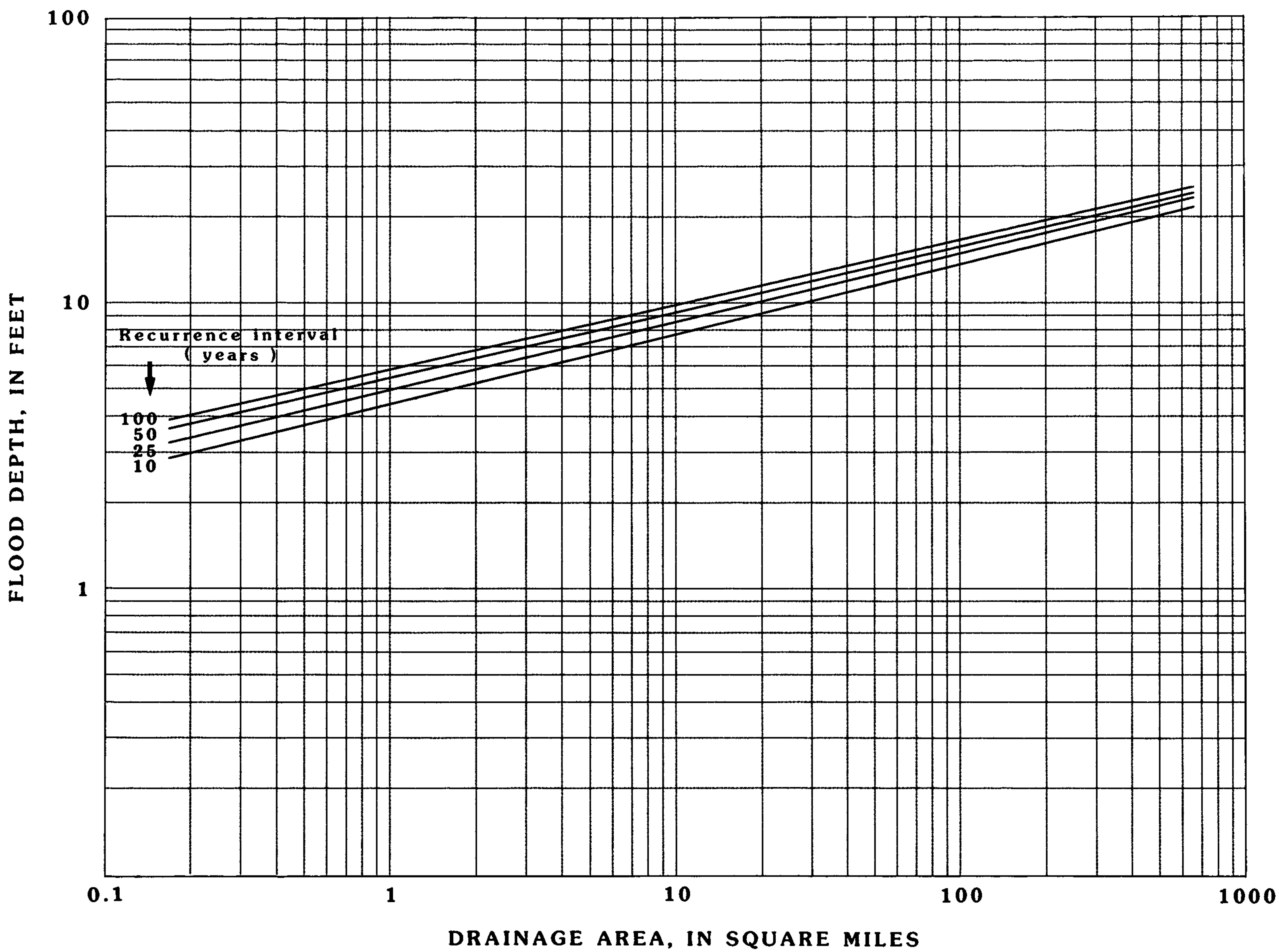

Figure 5.-- Relation of flood depth to drainage area for hydrologic area 3.

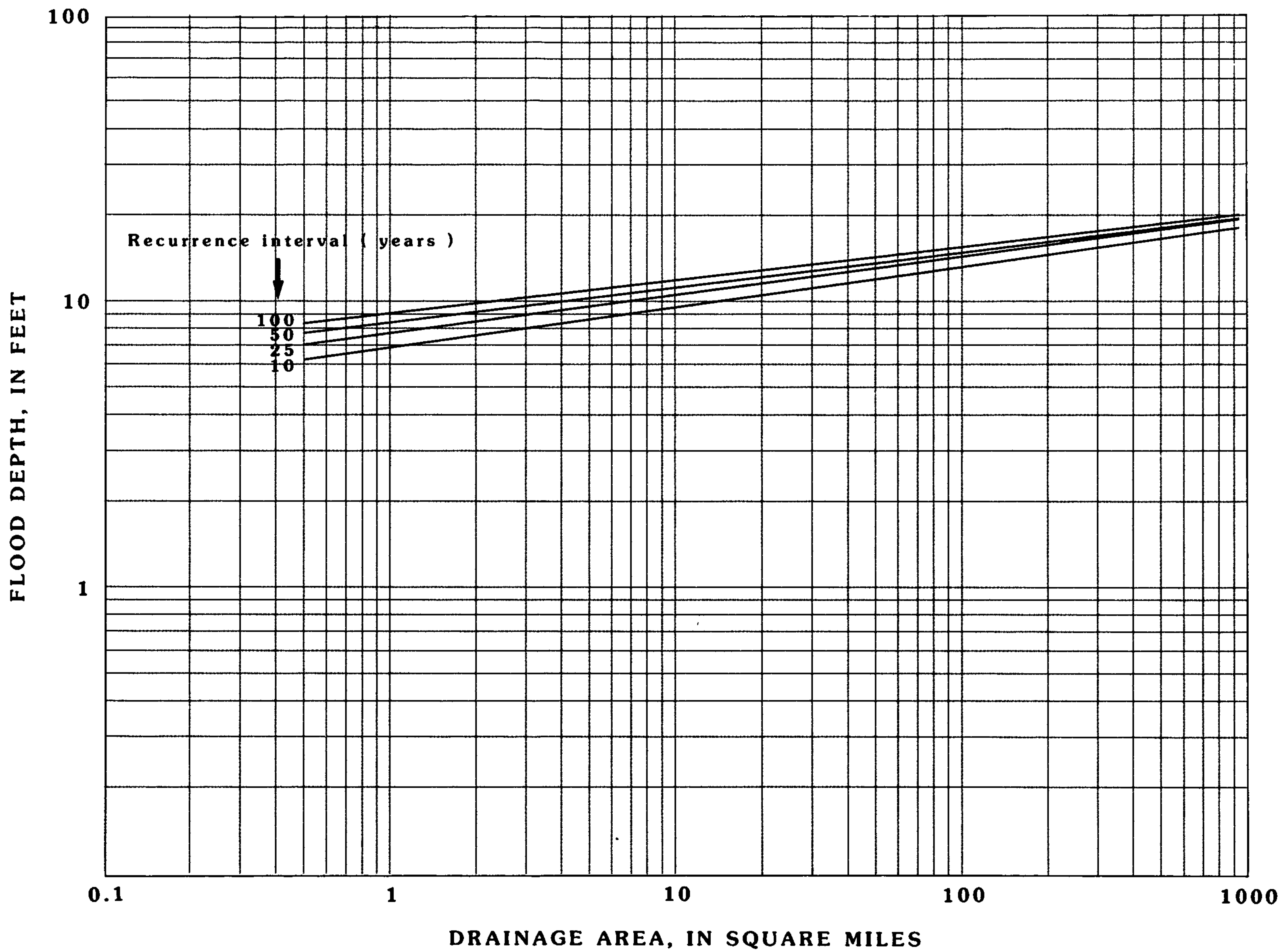

Figure 6.--Relation of flood depth to drainage area for hydrologic area 4.

APPLICATION OF RELATIONS

To determine the elevation of the 10-year or the 100-year flood at a given point on a stream, proceed as follows:

1. Determine the correct hydrologic area from figure 1.
2. Determine the drainage area of the stream, in square miles, from 7½-minute topographic maps.
3. Compute the depth of the 10-year or the 100-year flood using the appropriate equation from table 2 (or read from graphs on figure 3, 4, 5 or 6).
4. Add this depth to the median discharge elevation represented by contour crossings on 7½-minute topographic maps to obtain the elevation of the 10-year or the 100-year flood.

To determine the elevation for floods with recurrence intervals falling between the 10 and 100-years:

1. Determine the correct hydrologic area from figure 1.
2. Determine the drainage area at the site, in square miles, from 7½-minute topographic maps.
3. Enter figure 2 with the desired recurrence interval and pick off depth for 1 and 100 square miles from the appropriate hydrologic area curve.
4. Plot the values determined in step 3 on the appropriate figure 3, 4, 5, or 6 and draw a straight line through them.
5. Enter this graph with the drainage area determined in step 2 and read depth.
6. Add this depth to the median discharge elevation represented by contour crossings on 7½-minute topographic maps to obtain the elevation of the flood.

Slightly less accurate results can be obtained by eliminating steps 3 and 4 and interpolating between the lines of figures 3 to 6. If the drainage area of the site of interest is less than 1 square mile or greater than 100 square miles, use this method also.

On streams where reliable flood data are available, this data should be used to help define the desired flood depth or elevation or to appraise the validity of that computed by the above procedures. A profile of an actual flood is useful for this purpose. Most Federal agencies operating in Tennessee have various kinds of flood data in their files.

Boundaries of the four hydrologic areas (fig. 1) generally coincide with topographic divides. Consequently, for most streams, the entire basin is in one hydrologic area. For streams where parts of the basin are in two hydrologic areas, flood depths should be computed using the equation for each hydrologic area and the results weighted based on the percent of the basin in each hydrologic area.

Accuracy and Limitations

The accuracy of the regression equations can be expressed in terms of the standard error of estimate which is a measure of how well the actual depths used in the analysis agree with those computed by the regression equations. By definition, approximately two of three gaged sites have observed flood depths within one standard deviation on each side of the regression value. The standard error of estimate of the regressions for each hydrologic area is given in table 2. The standard error of prediction (total prediction error using the regression equations) may be somewhat larger (Hardison, 1971).

The regression equations are known to be applicable only within the range of drainage area sizes used in their definition. Reliability of the equations for estimating depths at sites outside the sample range is unknown. Therefore, the regression equations should be applied only to streams in Tennessee with basin sizes within the following ranges:

Hydrologic area 1	0.36 to 428 mi^2
Hydrologic area 2	.49 to 272 mi^2
Hydrologic area 3	.17 to 666 mi^2
Hydrologic area 4	.51 to 939 mi^2

Stations with larger drainage areas were not used because profiles and other data to estimate flood depths are available for most large streams in the offices of various Federal agencies operating in Tennessee.

This report is not intended to be used in making final decisions on land use. The results should be used only as a guide to decide if a more detailed investigation is needed. Their use in delineating flood boundaries on 7½-minute topographic maps should yield accuracies consistent with map production standards, which is one-half contour interval.

In West Tennessee (hydrologic area 4), dredging of the channels and construction of levees during the past several years have undoubtedly affected the flood characteristics, and consequently flood depths, of some streams. Randolph and Gamble (1976) state that "... the discharges of 50-year floods on small streams with a large improved channel may be as much as 100 percent larger than other streams in the vicinity without an improved channel." It seems obvious then, that discharges for the 10-year and the 100-year floods may also be larger for improved channels. Many of these improved channels in West Tennessee are of sufficient size to carry major floods within the channel. This means that a larger discharge is confined in a relatively narrow channel, hence a greater depth must occur than would have occurred in the natural channel. Limited data on streams with improved channels indicate that depth of floods is larger than that on unimproved channels in the same vicinity. However, the equations given in this report were not adjusted for improved channels because of insufficient data. Knowledge of whether the particular stream is improved is essential in applying the equation for West Tennessee. Most of the topographic maps in West Tennessee were prepared before about 1960 and, therefore, do not reflect recent channel changes.

Caution should be used in estimating flood depths at sites where the flow is significantly affected by constrictions, such as highway and railroad fills, across the flood plain. Two stations in west Tennessee were excluded from the analyses for this reason. Caution also should be used for stream sites in very narrow V-shaped valleys without a flood plain. Nine stations in central and east Tennessee were excluded from the analyses for these reasons. The relations given in this report tend to underestimate flood depths at such sites.

The relations given in this report may not be applicable to regulated streams, since the stream contour crossings shown on the topographic maps may not reflect the median discharge elevation and most regulated streams in Tennessee are larger than those used to define the relationships in this report. Also the discharge-frequency relation may be different for regulated streams.

REFERENCES

Gamble, C. R., and Lewis, J. G., 1977, Technique for estimating depth of 100-year floods in Tennessee: Nashville, Tennessee, U.S. Geological Survey Open-File Report 77-668, 18 p.

Gold, R. L., 1981, Low-flow frequency and flow duration of Tennessee streams: Nashville, Tennessee, U.S. Geological Survey Open-File Report 78-807, 361 p.

Hardison, C. H., 1971, Prediction error of regression estimates of streamflow characteristics at ungaged sites, in Geological Survey Research 1971: U.S. Geological Survey Professional Paper 750-C, p. C228-C236.

May, V. J., Wood, G. H., and Rima, D. R., 1970, A proposed streamflow-data program for Tennessee: Nashville, Tennessee, U.S. Geological Survey open-file report, 55 p.

Randolph, W. J., and Gamble, C. R., 1976, Technique for estimating magnitude and frequency of floods in Tennessee: Tennessee Department of Transportation, 52 p.