FLOOD MAGNITUDE AND FREQUENCY OF EIGHTMILE BRANCH TRIBUTARY AT THE CULVERT ON NEW JERSEY ROUTE 72, AT STAFFORD TOWNSHIP, NEW JERSEY

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CONVERSION FACTORS

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
foot per mile (ft/mi)	0.189	meter per kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

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ABSTRACT

Flood magnitude and frequency of Eightmile Branch tributary at the culvert on New Jersey Route 72, at Stafford Township, New Jersey, were determined by using a variation of the U.S. Geological Survey transfer method. Pre-development (1950) and post-development (1990) drainage-basin characteristics were used with the variation of the transfer method to produce the estimates. Flood magnitude and frequency estimates, as well as drainage-basin characteristics, are included in this report. The 100-year-flood estimates are 50 cubic feet per second for pre-development conditions and 62 cubic feet per second for post-development conditions.

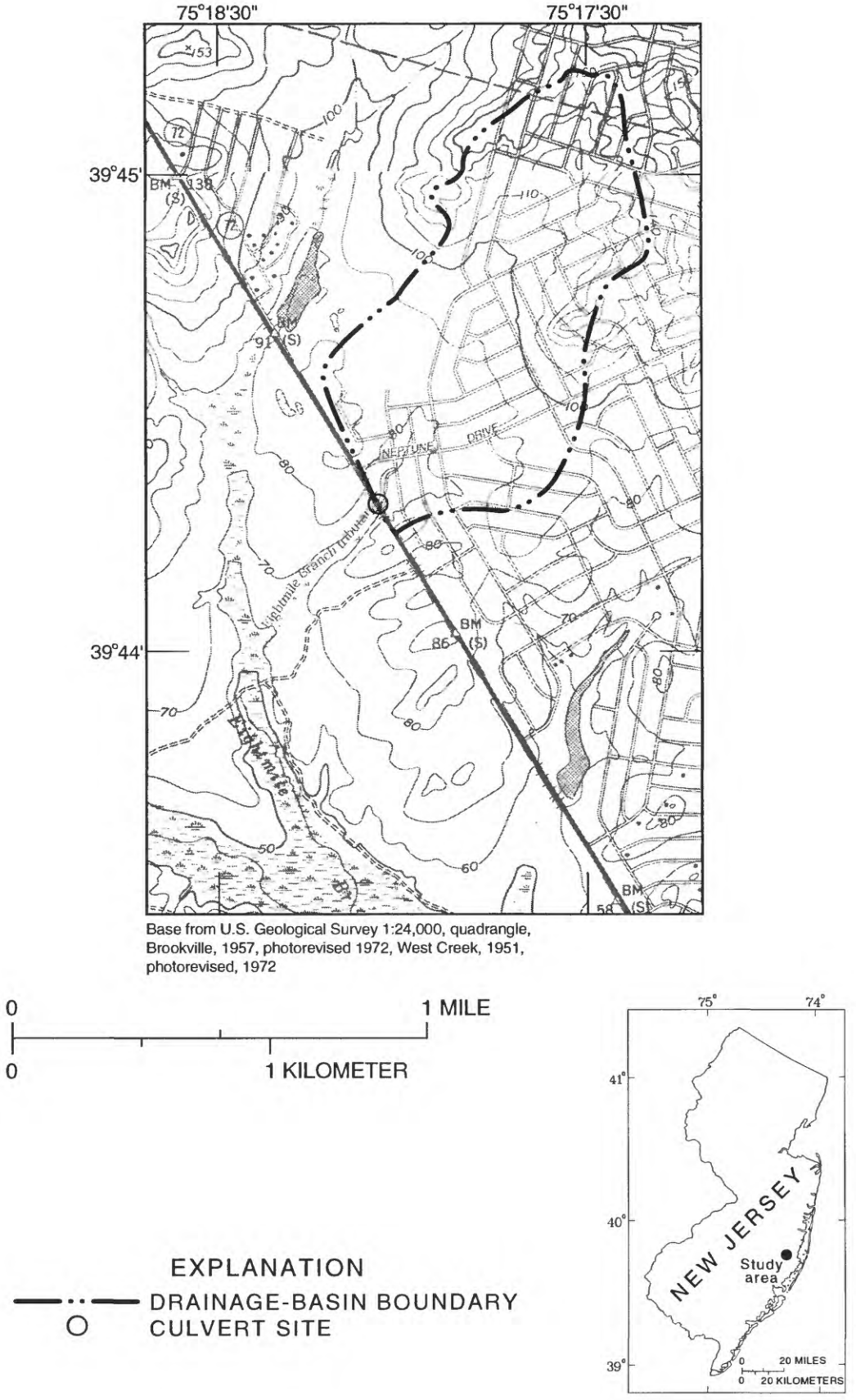
INTRODUCTION

Information on the magnitude and frequency of floods is critical to the planning and design of highway culverts and bridges. Such information is not readily available for many stream crossings in New Jersey. To fulfill this information need, the U.S. Geological Survey, in cooperation with the New Jersey Department of Transportation, began an analysis of flood data from stream-crossing sites on New Jersey streams. This report presents results of the analysis for Eightmile Branch tributary at the culvert on New Jersey Route 72, at Stafford Township, New Jersey. The culvert is located approximately one-tenth mile southeast of Neptune Drive at New Jersey Route 72 in Stafford Township, New Jersey (fig. 1). The drainage area above the site is 0.50 mi^2. A field reconnaissance was performed on September 27, 1994, to verify the locations of the drainage-basin divides and characteristics. Because the direction of storm-sewer drainage in some parts of the basin are uncertain, the calculated drainage area is approximate.

The flood-insurance study for Stafford Township (Federal Emergency Management Agency, 1979) did not include a detailed study of this stream; therefore, flood discharges were not determined previously.

METHODS FOR DETERMINING FLOOD MAGNITUDE AND FREQUENCY

Various methods for calculating flood magnitude and frequency were given consideration in determining the flood magnitudes that are likely to be exceeded at this site within a given number of years (recurrence interval). The rational method (Chow and others, 1988), New Jersey Department of Environmental Protection (NJDEP) Special Report 38 method (Stankowski, 1974), the U.S. Soil Conservation Service (SCS) Technical Release 55 (TR-55) method (U.S. Soil Conservation Service, 1986), and a variation of the U.S. Geological Survey (USGS) transfer method (New Jersey Department of Environmental Protection, 1993) were all given consideration in determining the flood magnitude and frequency of Eightmile Branch tributary at the culvert on New Jersey Route 72, at Stafford Township, New Jersey.



Base from U.S. Geological Survey 1:24,000, quadrangle, Brookville, 1957, photorevised 1972, West Creek, 1951, photorevised, 1972

Figure 1. Location of Eightmile Branch tributary at the culvert on New Jersey Route 72, at Stafford Township, New Jersey.

Special Report 38 typically produces overestimates of flood magnitude for some streamflow gaging stations near the Stafford Township site (Robert D. Schopp, U.S. Geological Survey, oral communication, 1994). Data from eighteen streamflow gages within a 30-mile radius of the culvert site were examined to confirm whether the Special Report 38 method consistently overestimates flood magnitude. Flood magnitude and frequency computed by using the Special Report 38 method were compared with the log-Pearson type III flood-frequency analysis for the 18 streamflow gages performed following documented guidelines (Interagency Advisory Committee on Water Data, 1982). In most cases, the Special Report 38 method overestimated by an average of 3 times the log-Pearson type III data (fig. 2). This bias most likely results from the presence of sandy soils and high-infiltration rates, which are common to the 30-mile radius area (Robert D. Schopp, U.S. Geological Survey, oral communication, 1994). Because the Special Report 38 method produces overestimates for this area, it is probably inappropriate to use this method for this culvert site.

The estimates of the 100-year flood made for the Route 72 site by using the rational method and the TR-55 method were 2.6 and 3.2 times, respectively, the estimates obtained by using the Special Report 38 method. Therefore, both of these methods also seem inappropriate for use at this culvert site.

A variation of the transfer method was chosen to estimate streamflow at the Eightmile Branch tributary at the culvert on New Jersey Route 72. Flood data from nearby streamflow or crest-stage gaging stations seem to provide the best estimate of the flood magnitude and frequency that can be expected at the ungaged culvert site, particularly, if drainage area and other basin characteristics are similar.

VARIATION OF THE TRANSFER METHOD (U.S. Geological Survey)

The relation that is traditionally used (New Jersey Department of Environmental Protection, 1993) to calculate flood estimates is based on a ratio of drainage areas raised to an exponent:

$$\frac{Q_{PI}}{Q_{PG}} = \left(\frac{A_{PI}}{A_{PG}}\right)^{0.75} ,$$

where Q_{PI} is the design flood at the point of interest, Q_{PG} is the design flood at the gaged point, A_{PI} is the drainage area at the point of interest, and A_{PG} is the drainage area at the gaged point. This method is recommended for drainage areas that are either less than twice or more than half the drainage area above the gaged point (New Jersey Department of Environmental Protection, 1993).

A variation of the transfer method is used to calculate flood estimates for Eightmile Branch tributary; it is based on a ratio of drainage basin characteristics:

$$\frac{Q_{PI}}{Q_{PG}} = \frac{A_i^w S_i^x St_i^y I_i^z}{A_g^w S_g^x St_g^y I_g^z} ,$$

where Q_{PI} is the design flood at the point of interest, Q_{PG} is the design flood at the gaged point, A_i and A_g are the drainage areas, S_i and S_g are the main-channel slopes, St_i and St_g are the surface storage indexes, and I_i and I_g are the indexes of manmade impervious cover at the point of interest and at the

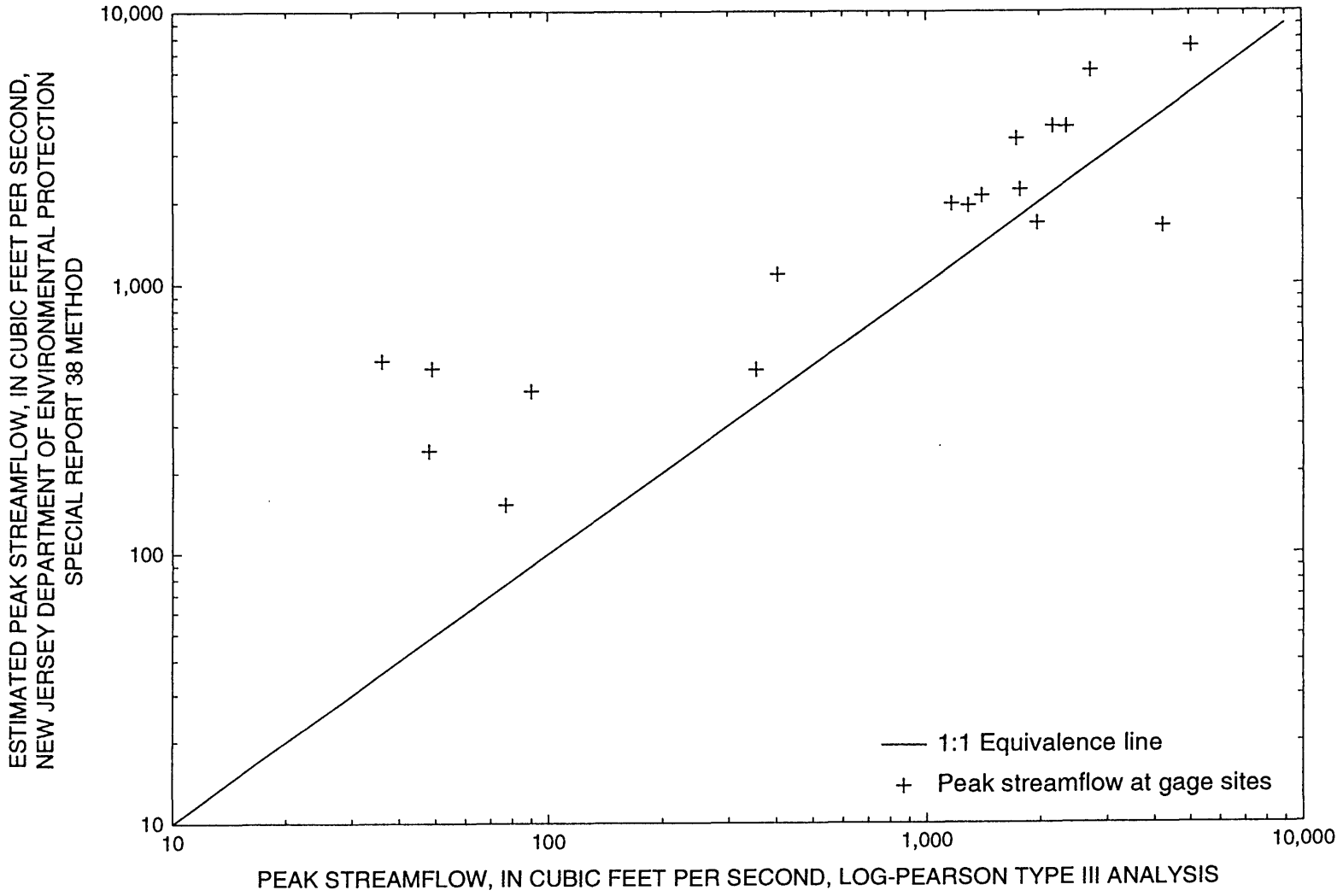


Figure 2. Relation of 100-year peak streamflow determined by using log-Pearson type III analysis of observed data to estimated 100-year peak streamflow determined by using New Jersey Department of Environmental Protection Special Report 38 method at 18 streamflow and crest-stage gages within a 30-mile radius of Eightmile Branch tributary at the culvert on New Jersey Route 72, at Stafford Township, New Jersey.

gaged point, respectively. The variables chosen for this method are based on those used in the New Jersey Department of Environmental Protection Special Report 38 method (Stankowski, 1974). The exponents w, x, y, and z vary according to recurrence interval and are the same as those used in the Special Report 38 method. Although the Special Report 38 method overestimates the log-Pearson type III data, a ratio of the drainage-basin characteristics used in the Special Report 38 method allows the characteristics to be considered when adjusting flows from a nearby gaging station to the culvert site without bias from local drainage-basin and geologic conditions.

RESULTS

Flood data from nearby streamflow or crest-stage gaging stations provide a good indication of the flood magnitude and frequency that can be expected at an ungaged site, particularly when drainage area and other basin characteristics are similar. In this study, estimates obtained by using a variation of the USGS transfer method with data collected at three nearby crest-stage gages (station numbers 01409403, 01409375, and 01409409) and two nearby streamflow-gaging stations (station numbers 01466000 and 01466500) were averaged to provide a high degree of accuracy. Of the 18 streamflow and crest-stage gaging stations within a 30-mile radius of the culvert at New Jersey Route 72, Stafford Township, New Jersey, these five stations were chosen because their drainage-basin characteristics are similar to those at the culvert site.

The explanatory variables used in applying the variation of the transfer method for both pre-development (1950) and post-development (1990) conditions at the culvert site are listed in tables 1 and 2, respectively. Population density, which is related to impervious area, (Stankowski, 1974) was the only variable that changed over time. Table 3 lists drainage-basin characteristics and discharges at gaging stations used in applying the variation of the transfer method. The flood-magnitude and -frequency estimates for both 1950 and 1990 are shown in table 4. The estimate of the 100-year flood discharge at the culvert site for pre-development conditions is 50 ft^3/s. The estimate of the 100-year flood discharge at the culvert site for post-development conditions is 62 ft^3/s.

Table 1. Explanatory variables for the variation of the U.S. Geological Survey transfer method, pre-development conditions (1950), Eightmile Branch tributary, Stafford Township, New Jersey

Drainage area: 0.50 square miles
Latitude: 39°44'18"
Longitude: 74°18'03"
Highway: New Jersey Route 72
U.S. Geological Survey 7-1/2-minute quadrangle: West Creek

Variable	Value	Unit
Drainage area	= 0.50	(square miles)
Main channel slope	= 64.4	(feet per mile)
Surface storage index	= 1.0	
Total stream length	= 1.2	(miles)
Population density (1950)	= 28.3	(persons per square mile)
Manmade impervious cover index	= 1.4	(percent)
Lake and swamp area	= .0	(percent)

Table 2. Explanatory variables for the variation of the U.S. Geological Survey transfer method, post-development conditions (1990), Eightmile Branch tributary, Stafford Township, New Jersey

Drainage area: 0.50 square miles
Latitude: 39°44'18"
Longitude: 74°18'03"
Highway: New Jersey Route 72
U.S. Geological Survey 7-1/2-minute quadrangle: West Creek

Variable	Value	Unit
Drainage area	= 0.50	(square miles)
Main channel slope	= 64.4	(feet per mile)
Surface storage index	= 1.0	
Total stream length	= 1.2	(miles)
Population density (1990)	=260.0	(persons per square mile)
Manmade impervious cover index	= 1.4	(percent)
Lake and swamp area	= .0	(percent)

Table 3. Drainage-basin characteristics and discharge values from log-Pearson type III flood-frequency analysis for streamflow-gaging and crest-stage gaging stations used in the variation of the U.S. Geological Survey transfer method

[Q, flood-magnitude estimates in cubic feet per second along with number indicating the frequency of the recurrence interval, in years; DA, drainage area, in square miles; S, main-channel slope, in feet per mile; St, surface storage index, in percent of drainage area; I, index of manmade impervious cover, in percent of drainage area; YR, years of record; D, distance, in miles, of station from flood site]

Gaging station number	Q2	Q5	Q10	Q25	Q50	Q100	DA	S	St	I	YR	D
Station 01409375	32	46	55	69	79	90	3.22	12.7	5.6	19.0	13	30.0
Station 01409403	9.6	15	20	26	31	36	1.03	45.7	1.0	10.3	13	29.7
Station 01409409	12	20	26	34	41	49	3.01	14.5	3.5	15.9	11	29.5
Station 01466000	13	22	31	45	59	76	2.82	12.3	16.9	1.3	25	16.5
Station 01466500	10	17	23	31	39	48	2.35	18.4	6.1	1.2	37	14.9

Table 4. Flood-magnitude estimates for given flood frequencies using the variation of the U.S. Geological Survey transfer method, Eightmile Branch tributary, Stafford Township, New Jersey

[Q, flood-magnitude estimates in cubic feet per second along with number indicating the frequency of the recurrence interval, in years; DA, drainage area, in square miles; S, main-channel slope, in feet per mile; St, surface storage index, in percent of drainage area; I, index of manmade impervious cover, in percent of drainage area]

Drainage area: 0.50 square miles
Latitude: 39°44'18"
Longitude: 74°18'03"
Highway: New Jersey Route 72
U.S. Geological Survey 7-1/2-minute quadrangle: West Creek

	Q2	Q5	Q10	Q25	Q50	Q100	DA	S	St	I
Pre-development (1950)	11	17	23	32	39	50	0.5	64.4	1.0	1.4
Post-development (1990)	16	24	31	42	50	62	0.5	64.4	1.0	5.7

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