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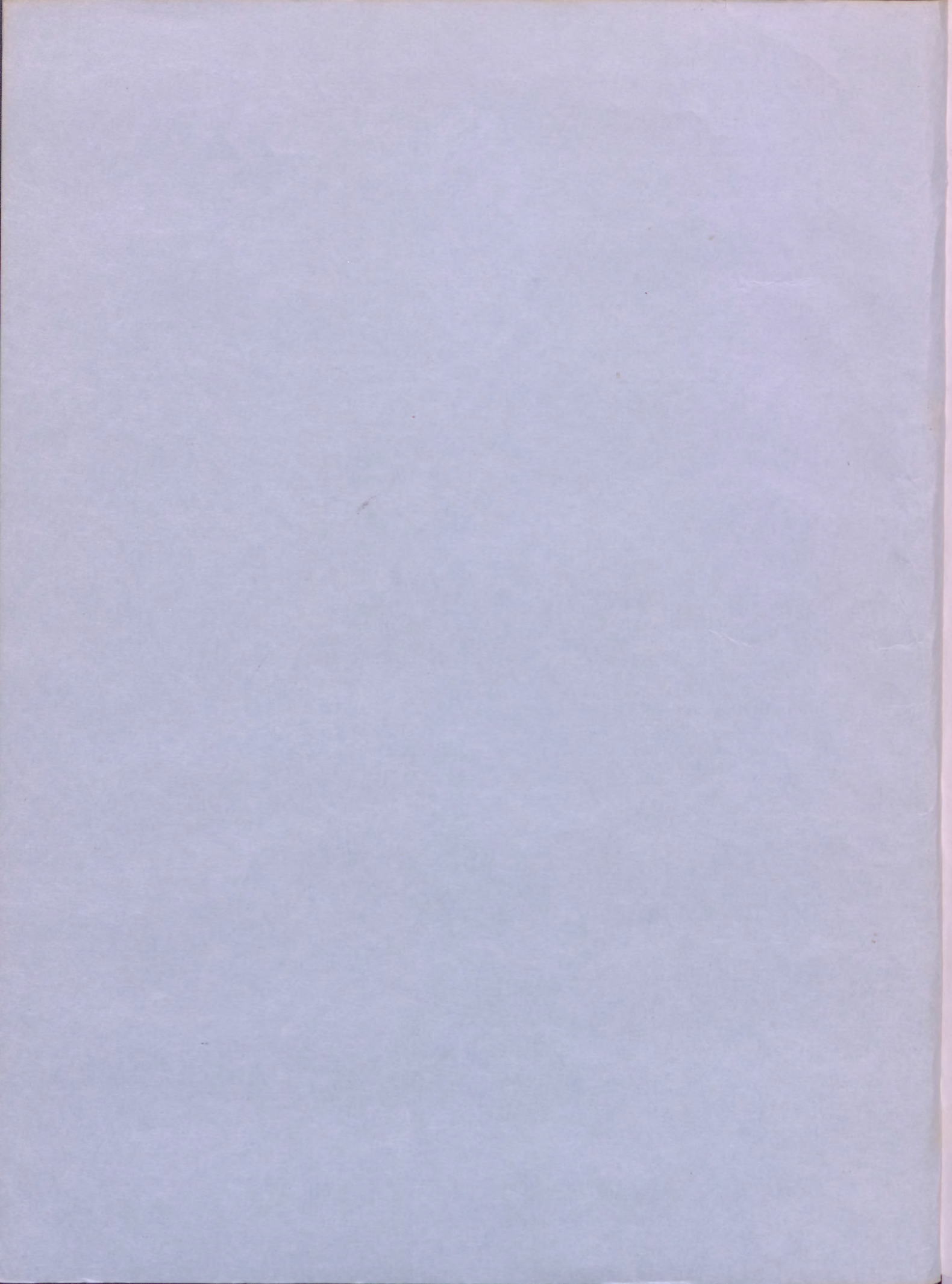UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FLOODFLOW CHARACTERISTICS OF

BUTTERNUT CREEK AND JAMESVILLE RESERVOIR,

JAMESVILLE, ONONDAGA COUNTY, NEW YORK

Open-File Report 79-1292

Prepared in cooperation with

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Albany, New York
September 1979

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Multiply inch-pound units	By	To obtain SI units
inch (in)	2.54×10^1	millimeter (mm)
	2.54×10^0	centimeter (cm)
	2.54×10^{-2}	meter (m)
foot (ft)	3.048×10^{-1}	meter (m)
mile (mi)	1.609×10^0	kilometer (km)
square mile (mi^2)	2.590×10^0	square kilometer (km^2)
feet per mile (ft/mi)	1.894×10^{-1}	meters per kilometer (m/km)
cubic feet per second (ft^3/s)	2.832×10^1	liters per second (L/s)
	2.832×10^{-2}	cubic meters per second (m^3/s)

FLOODFLOW CHARACTERISTICS OF BUTTERNUT CREEK

AND JAMESVILLE RESERVOIR, JAMESVILLE,

ONONDAGA COUNTY, NEW YORK

by

Bernard Dunn

ABSTRACT

A hydrologic study of Butternut Creek, near Jamesville, Onondaga County, N.Y., was done to develop inflow and outflow hydrographs of the "probable maximum flood" and the "standard project flood" of Jamesville Reservoir, as defined by the U.S. Army Corps of Engineers. The inflow and outflow discharges of the probable maximum flood were computed to be 23,600 and 23,100 cubic feet per second, respectively, and of the standard project flood, 9,400 and 8,800 cubic feet per second, respectively. A rating curve computed for the dam spillway indicates that water-surface elevations produced at the dam by runoff from both the standard project flood and the maximum probable flood would be above the top of the spillway abutments. The 10- and 100-year peak discharges at the Butternut Creek gaging station were computed by the HEC-1 program of the Corps of Engineers to be 2,160 and 3,450 cubic feet, respectively, as compared to 1,680 and 2,810 cubic feet per second computed by a log-Pearson Type III analysis of the station data. The HEC-1 values are within the 5- and 95-percent confidence limits of the log-Pearson Type III values.

INTRODUCTION

An inspection of Jamesville Reservoir by the U.S. Army Corps of Engineers in 1978 revealed a structural condition that raised concern as to the dam's safety. In response, the New York State Department of Transportation requested the U.S. Geological Survey to make a hydrologic study of Jamesville Reservoir and of Butternut Creek, the main source to the reservoir.

The study entailed (1) computation of inflow and outflow hydrographs of the reservoir for the probable maximum flood and the standard project flood as defined by the U.S. Army Corps of Engineers; (2) computation of the stage/outflow relationship for the Jamesville Reservoir dam spillway; (3) calculation of the 10- and 100-year flood discharges at the Butternut Creek gage, 2.2 miles upstream from the reservoir, using (a) the Corps of Engineers' HEC-1 program, which is based on rainfall records, and (b) the log-Pearson type III analysis, which is based on streamflow records.

Inflow and outflow values of the probable maximum flood and the standard project flood at Jamesville Reservoir were developed from the probable maximum precipitation values as derived by the U.S. Weather Bureau (1956). Outflow from the reservoir during each of these floods was computed on the assumption that all flow would be over the spillway of the dam. The estimates determined from the HEC-1 model for the peak discharges of the 10- and 100-year floods at Butternut Creek gaging station are in close agreement with log-Pearson Type III estimates at the gaged site. Further agreement was obtained by reproducing a reported peak stage at the dam.

Physical Setting

Butternut Creek is the principal inflowing stream to Jamesville Reservoir. Since July 1958, the Geological Survey has maintained a gaging station (no. 04245200) on Butternut Creek at Walberger Road, 2.2 mi upstream from the reservoir. The drainage area at the gage is 32.2 mi^2; drainage area at the Jamesville Reservoir dam is 43.8 mi^2. Figure 1 is a map of the area showing features pertinent to this study.

The Jamesville Reservoir is formed by a masonry stone gravity dam built in 1872-74. The spillway is 205 ft long and has a crest elevation of 639.5 ft above National Vertical Geodetic Datum. The elevation of the top of the abutments on either side of the spillway is 645.0 ft. Outflow from the reservoir is regulated by three 24-inch pipes, each controlled by a 12-inch gate valve. These valves are usually set to approximately 4-inch openings. About 600 ft west of the spillway is a saddle dam. The lowest point of the saddle dam is at an elevation of 643.5 ft, which is 1.5 ft lower than the top of the abutments of the crest spillway. The New York State Department of Transportation plans to fill the saddle dam to eliminate any possible flow.
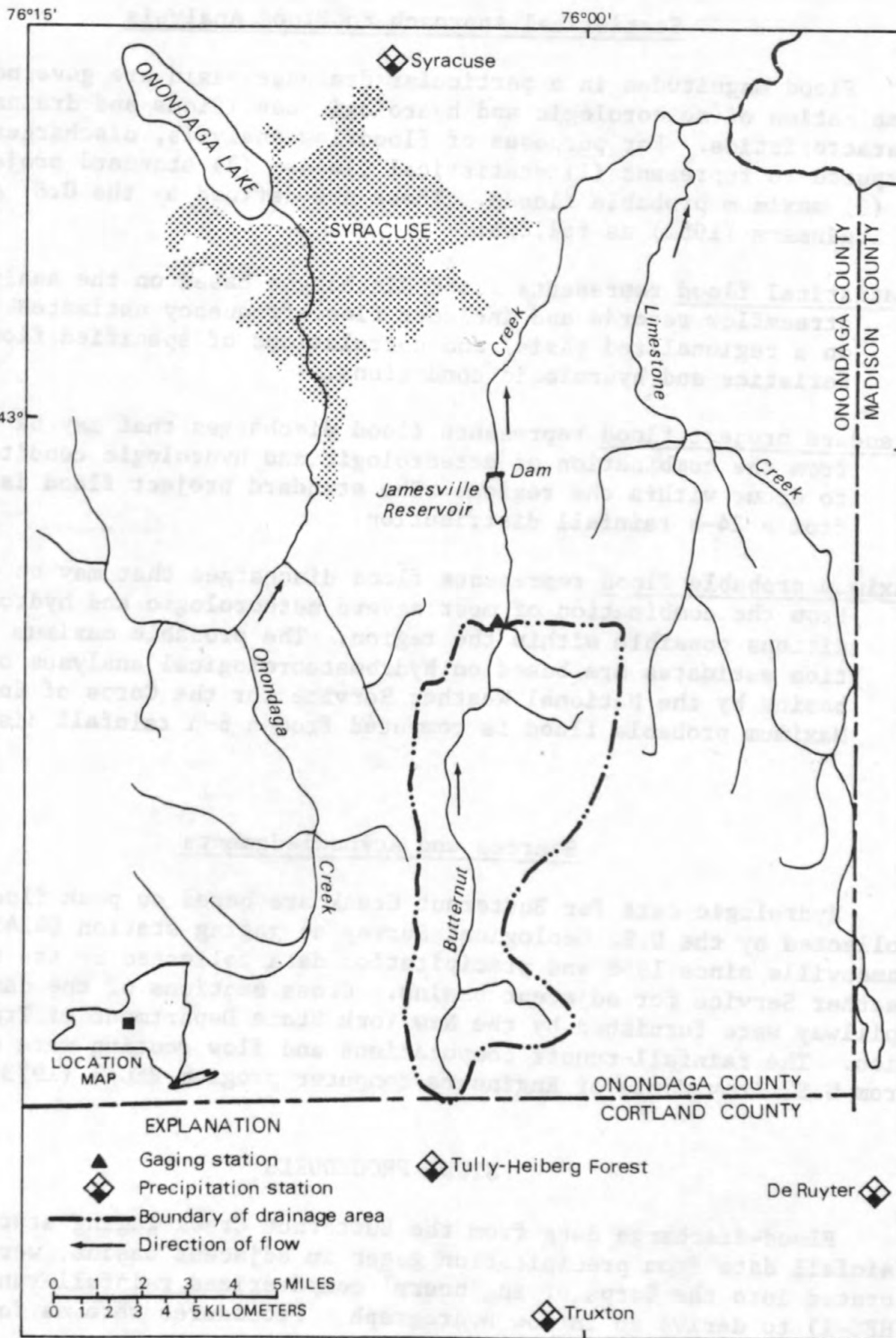
Figure 1.--Major features of Jamesville Reservoir and Butternut Creek area, Onondaga County, N.Y.

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Statistical Approach to Flood Analysis

Flood magnitudes in a particular drainage basin are governed by a combination of meteorologic and hydrologic conditions and drainage-basin characteristics. For purposes of floodflow analysis, discharges may be computed to represent (1) statistical floods, (2) standard project floods, or (3) maximum probable floods. These are defined by the U.S. Army Corps of Engineers (1952) as follows:

Statistical flood represents flood discharges based on the analysis of streamflow records and includes flood-frequency estimates (preferably on a regionalized basis) and correlations of specified flood characteristics and hydrologic conditions.

Standard project flood represents flood discharges that may be expected from the combination of meteorologic and hydrologic conditions likely to occur within the region. The standard project flood is computed from a 24-h rainfall distribution.

Maximum probable flood represents flood discharges that may be expected from the combination of most severe meteorologic and hydrologic conditions possible within the region. The probable maximum precipitation estimates are based on hydrometeorological analyses of individual basins by the National Weather Service for the Corps of Engineers. Maximum probable flood is computed from a 6-h rainfall distribution.

Sources and Acknowledgments

Hydrologic data for Butternut Creek are based on peak flood data collected by the U.S. Geological Survey at gaging station 04245200 near Jamesville since 1958 and precipitation data collected by the National Weather Service for adjacent basins. Cross sections of the dam and spillway were furnished by the New York State Department of Transportation. The rainfall-runoff computations and flow routing were obtained from U.S. Army Corps of Engineers computer program HEC-1 (1973).

STUDY PROCEDURES

Flood-discharge data from the Butternut Creek gaging station, and rainfall data from precipitation gages in adjacent basins, were incorporated into the Corps of Engineers' computerized rainfall-runoff program (HEC-1) to derive an inflow hydrograph. Procedures were as follows:

1. Physiographic characteristics of the watershed, such as area and length, were determined for (a) the drainage basin upstream from the dam, and (b) the drainage basin upstream from the gaging station. These values were incorporated into the HEC-1 program.

2. Unit (hourly) hydrographs at the gaging station were developed for five selected floods.

3. One of the unit hydrographs was selected as the average for the stream at the gaging station and was used to develop values for the standard project flood and maximum probable flood.

4. Hypothetical storm-runoff values that would produce the 10-year and 100-year flood at the gaging station were developed from precipitation data from U.S. Weather Bureau (1956, 1961).

5. Hydrographs of discharge, based on storm-runoff values resulting from (a) the standard project flood, and (b) the maximum probable flood, into the reservoir, were developed.

6. Hydrographs of outflow from the reservoir were computed for the two floods by the Modified Puls reservoir routing technique (Chow, 1964). An elevation/storage relationship was developed by planimetry from U.S. Geological Survey topographic maps. The elevation of the reservoir pool at the beginning of each storm event was assumed to be at the crest of the spillway.

7. A spillway discharge-rating curve was computed on the assumption that the spillway acts as a broad-crested weir (Hulsing, 1968). The three 12-inch manual gate valves were assumed to be closed so that the computations would represent the most severe conditions.

8. HEC-1 model results were compared with log-Pearson estimates and with computed values of a selected storm.

Unit Hydrograph Derivation

A unit hydrograph, or unit graph, is a hydrograph representing flows that result from 1 inch of direct runoff from a storm distributed uniformly over the drainage basin during a specified unit of time. The assumptions in the derivation of the unit-hydrograph theory (Chow, 1964, p. 14-13) are as follows:

1. Rainfall is distributed uniformly within the specified time period.

2. Rainfall is distributed uniformly throughout the drainage basin.

3. Time intervals of the direct-runoff hydrograph are constant.

4. The ordinates of the direct-runoff hydrographs of a common time period are directly proportional to the total amount of direct runoff represented by each hydrograph.

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5. Runoff from a given period of rainfall reflects the combined physical characteristics of the basin.

The standard procedure where streamflow records are available is to choose four or five large-magnitude rainstorms for which runoff hydrographs are available. These hydrographs are used to develop unit hydrographs from which an average unit hydrograph for the basin can be derived (Gray, 1970).

Streamflow records for Butternut Creek (station 04245200) have been published annually since 1958 by the U.S. Geological Survey. From these records, storms with uniform areal distribution and a runoff near or greater than 1.0 inch were examined for use in developing unit hydrographs. All events affected by snowmelt were eliminated. The five storms selected for analysis were:

June 15, 1972	April 16, 1976
July 4, 1974	October 9, 1976
September 26, 1975	

A unit hydrograph for each of these floods, developed from the computer program HEC-1, is given in figure 2. The unit hydrograph for the storm of October 9, 1976, was determined to represent the average of the five events.

Jamesville Reservoir Unit Hydrograph

The unit-hydrograph data derived for the gage site were transferred to the reservoir using a regional equation relating Snyder's standard basin lag (t_p) (time difference between the centroid of the unit rainfall and unit hydrograph peak discharge) and physical basin characteristics. The equation is expressed as:

$$t_p = 1.2 \ (L \times Lea)^{0.30}$$

where:

   t_p = Snyder's standard lag, in hours

   L = length along longest watercourse from outflow point of subbasin to upper limit of watershed boundary, in miles

   Lea = length of watercourse from outflow point to the point opposite the center of gravity of the drainage basin, in miles.

The coefficient of 1.2, known as Snyder's C_t, was the average value for the five floods analyzed. Snyder's C_t is a regional coefficient that depends on basin slopes, stream patterns, basin shape, and other hydrologic properties of the area.
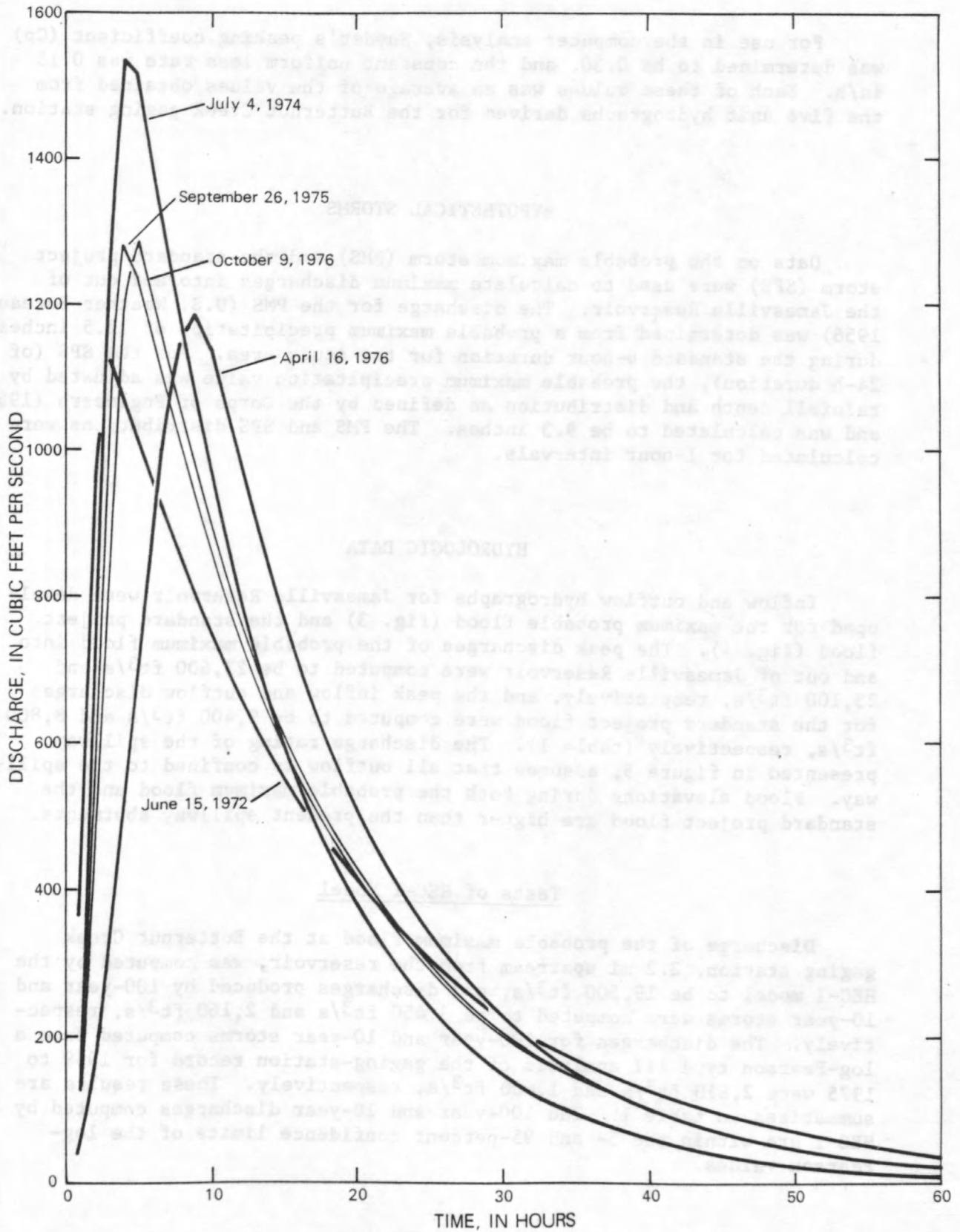
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Figure 2.--Unit hydrographs derived at Butternut Creek gaging station near Jamesville, N.Y.

For use in the computer analysis, Snyder's peaking coefficient (Cp) was determined to be 0.30, and the constant uniform loss rate was 0.15 in/h. Each of these values was an average of the values obtained from the five unit hydrographs derived for the Butternut Creek gaging station.

HYPOTHETICAL STORMS

Data on the probable maximum storm (PMS) and the standard project storm (SPS) were used to calculate maximum discharges into and out of the Jamesville Reservoir. The discharge for the PMS (U.S. Weather Bureau, 1956) was determined from a probable maximum precipitation of 22.5 inches during the standard 6-hour duration for the study area. For the SPS (of 24-h duration), the probable maximum precipitation value was adjusted by rainfall depth and distribution as defined by the Corps of Engineers (1952) and was calculated to be 9.3 inches. The PMS and SPS distributions were calculated for 1-hour intervals.

HYDROLOGIC DATA

Inflow and outflow hydrographs for Jamesville Reservoir were developed for the maximum probable flood (fig. 3) and the standard project flood (fig. 4). The peak discharges of the probable maximum flood into and out of Jamesville Reservoir were computed to be 23,600 ft³/s and 23,100 ft³/s, respectively, and the peak inflow and outflow discharges for the standard project flood were computed to be 9,400 ft³/s and 8,800 ft³/s, respectively (table 1). The discharge rating of the spillway, presented in figure 5, assumes that all outflow is confined to the spillway. Flood elevations during both the probable maximum flood and the standard project flood are higher than the present spillway abutments.

Tests of HEC-1 Model

Discharge of the probable maximum flood at the Butternut Creek gaging station, 2.2 mi upstream from the reservoir, was computed by the HEC-1 model to be 19,500 ft³/s, and discharges produced by 100-year and 10-year storms were computed to be 3,450 ft³/s and 2,160 ft³/s, respectively. The discharges for 100-year and 10-year storms computed from a log-Pearson type III analysis of the gaging-station record for 1959 to 1975 were 2,810 ft³/s and 1,680 ft³/s, respectively. These results are summarized in table 1. The 100-year and 10-year discharges computed by HEC-1 are within the 5- and 95-percent confidence limits of the log-Pearson values.
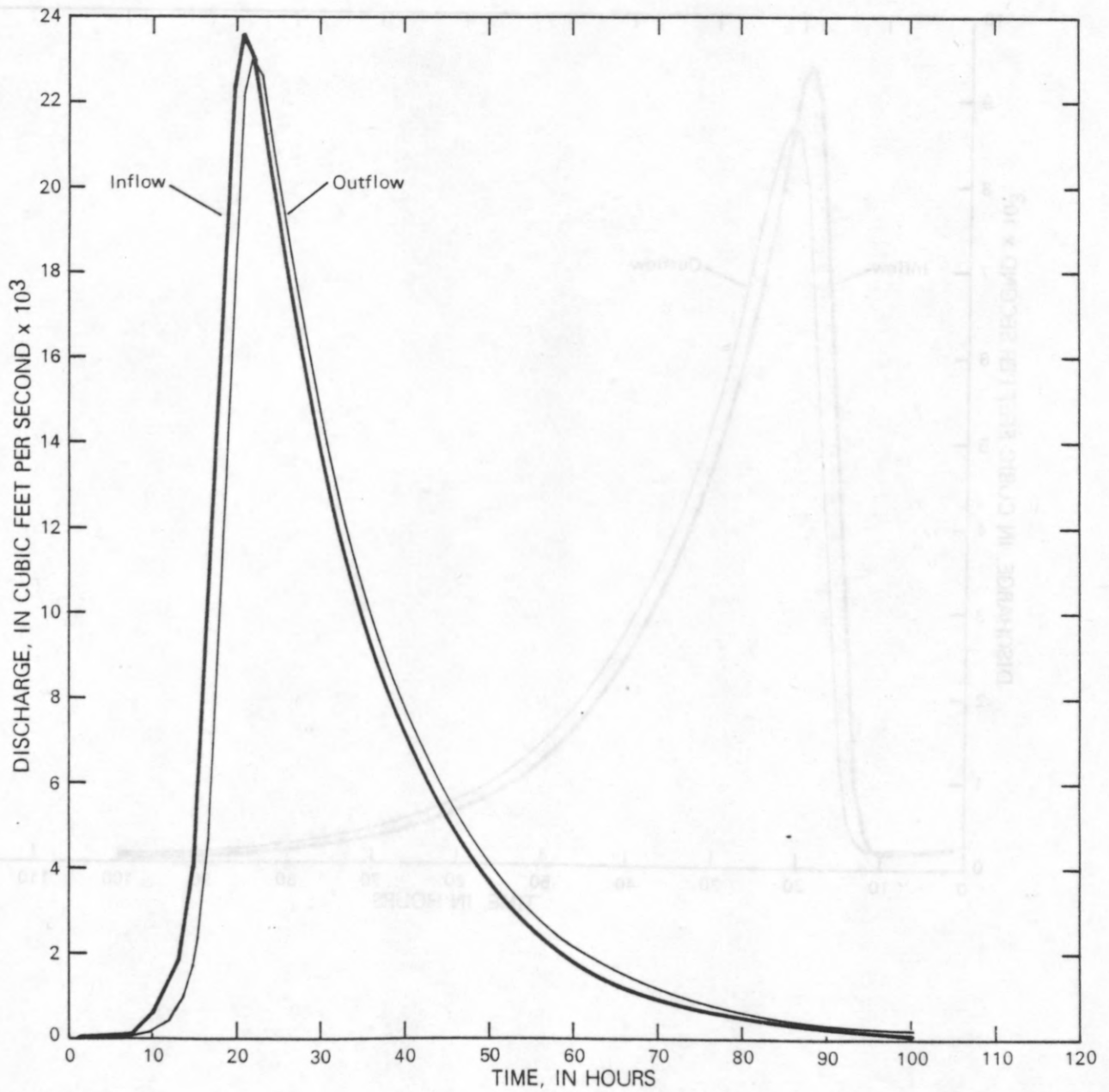
Figure 3.--Inflow and outflow hydrographs for probable maximum flood, Jamesville Reservoir.
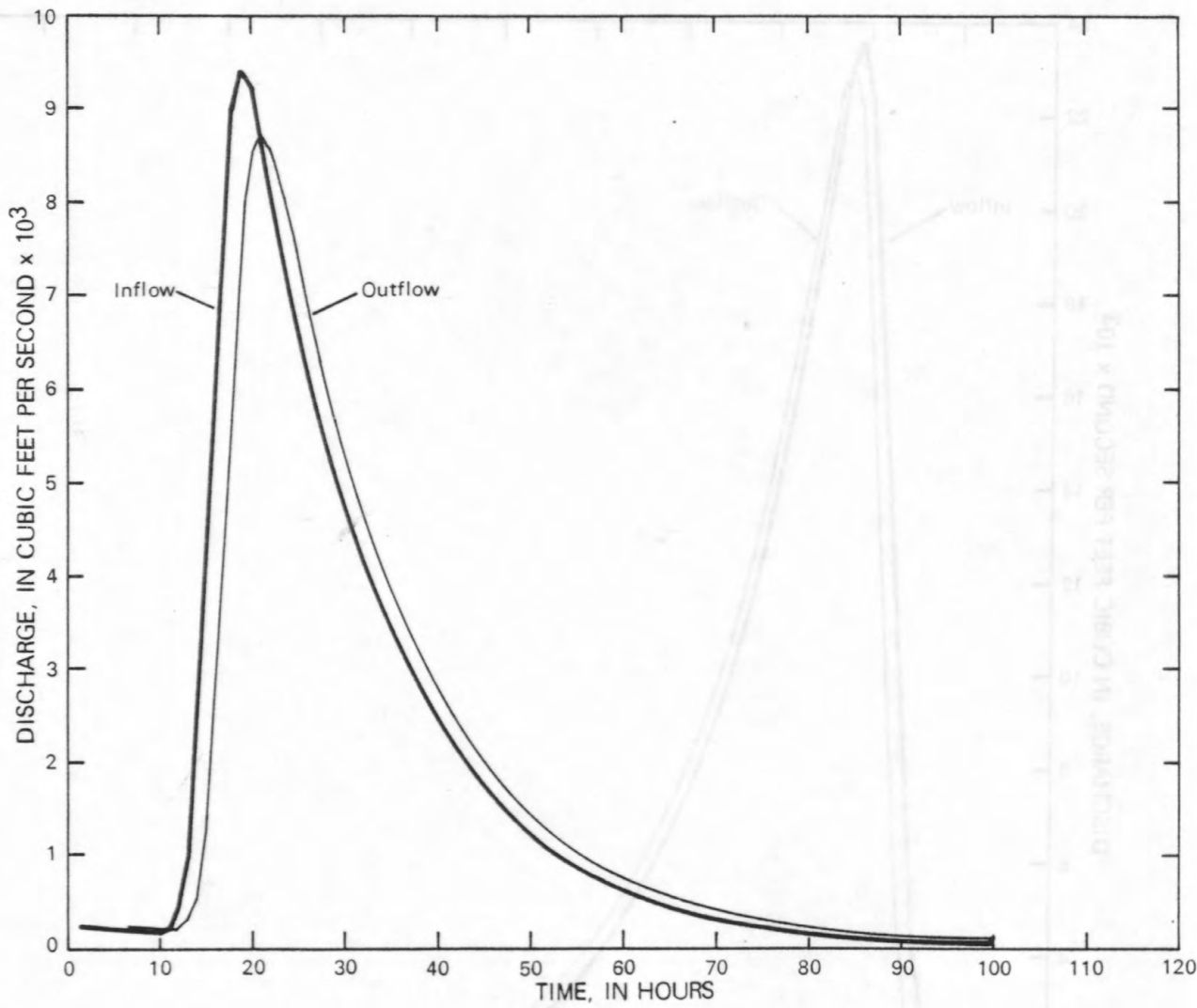
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Figure 4.--Inflow and outflow hydrographs for standard project flood, Jamesville Reservoir.
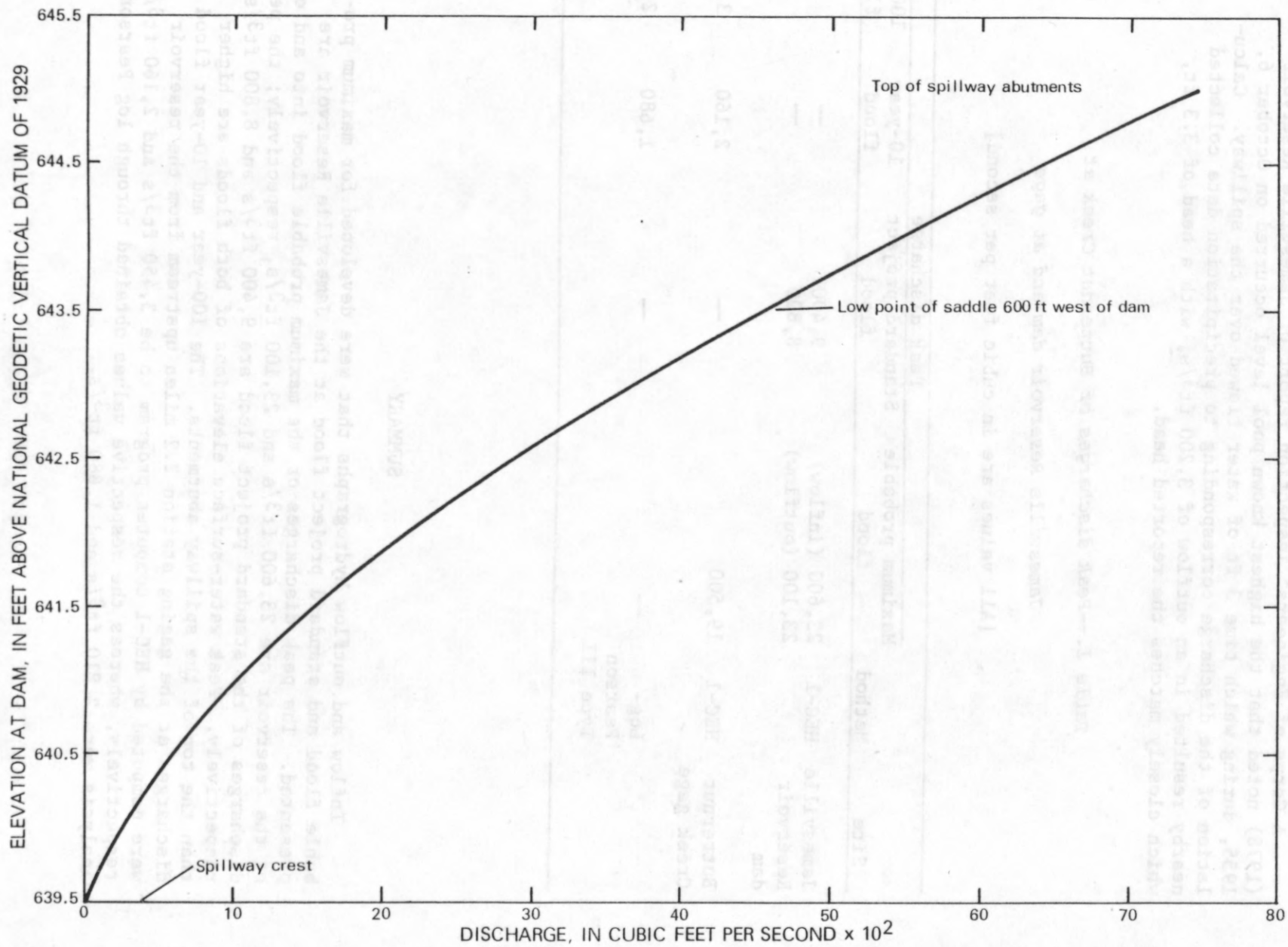
Figure 5.--Spillway rating curve, Jamesville Reservoir.

A Corps of Engineers' inspection report of Jamesville Reservoir (1978) noted that the highest known pool level occurred on October 6, 1955, during which time 3 ft of water flowed over the spillway. Calculation of the discharge corresponding to precipitation data collected nearby resulted in an outflow of 3,200 ft³/s, with a head of 3.3 ft, which closely matches the reported head.

Table 1.--*Peak discharges of Butternut Creek at*

Jamesville Reservoir dam and at gage
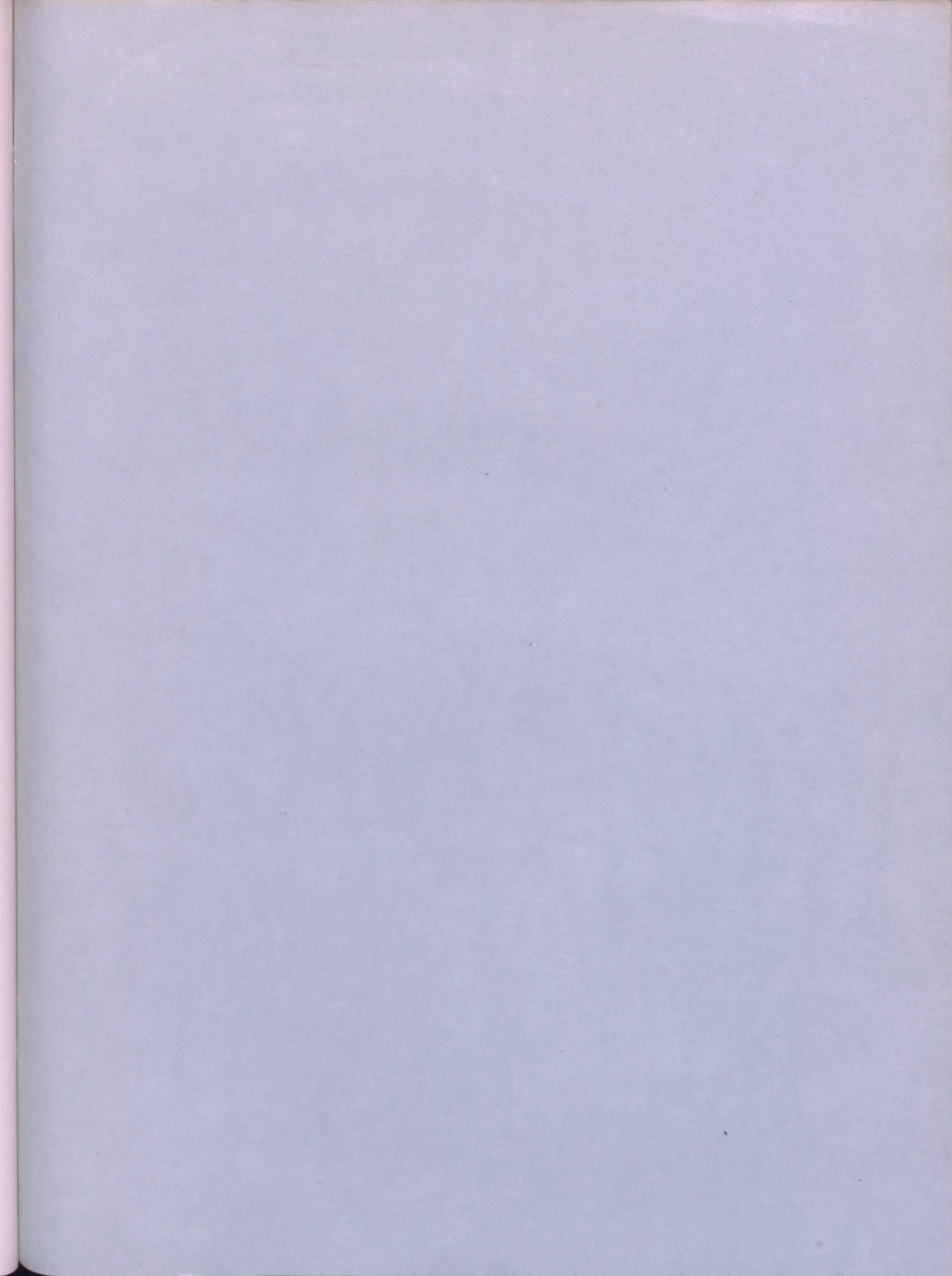
[All values are in cubic feet per second]

Site	Method	Peak discharge			
		Maximum probable flood	Standard project flood	10-year flood	100-year flood
Jamesville Reservoir dam	HEC-1	23,600 (inflow) 23,100 (outflow)	9,400 8,800	-- --	-- --
Butternut Creek gage	HEC-1	19,500	--	2,160	3,450
	Log-Pearson Type III	--	--	1,680	2,810

SUMMARY

Inflow and outflow hydrographs that were developed for maximum probable flood and standard project flood at the Jamesville Reservoir are presented. The peak discharges of the maximum probable flood into and out of the reservoir are 23,600 ft³/s and 23,100 ft³/s, respectively; the peak discharges of the standard project flood are 9,400 ft³/s and 8,800 ft³/s, respectively. Peak water-surface elevations of both floods are higher than the top of the spillway abutments. The 100-year and 10-year flood discharges at the gaging station 2.2 miles upstream from the reservoir were computed by HEC-1 computer program to be 3,450 ft³/s and 2,160 ft³/s, respectively, whereas the respective values obtained through log Pearson analysis were 2,810 ft³/s and 1,680 ft³/s.

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