

Stream Discharge and Large Flood Frequency

Part A - Stream Discharge is the quantity (volume) of water passing by a given point in a certain amount of time. It is calculated as $Q = V * A$, where V is the stream velocity and A is the stream's cross-sectional area. Units of discharge are volume per time (e.g., m^3/sec or million gallons per day, mgpd).

The Wild River has a cross-sectional profile that is approximately rectangular with a width of 20 m, an average depth of 2 m, and an average velocity of 1.9 m/s.

The Paux River has a cross-sectional profile that is approximately semicircular with a width of 40 m, a depth of 20 m, and an average velocity of 0.9 m/s. (*hint: look up the formula for the area of a circle*)

- 1) Calculate the discharge for each.
- 2) Which has the greatest discharge? What does that mean?

Part B - Floods and Recurrence Interval

Recurrence intervals, or the predicted average time between flood discharges of a given size can be estimated from historic records of annual peak discharges on a stream with records for a sufficiently long number of years. From recurrence interval plots, geologists can predict the average time between floods of a given size or they can be used to determine the size of the discharge for "10 year, 50 year, and 100 year floods," etc. A 100 year flood is simply the peak discharge of a size that should be equaled or exceeded on average once in 100 years. The probability of equaling or exceeding the peak discharge of a "100 year flood" in any given year is 1 percent. A 100 year flood could happen in any given year. They are not spread evenly in time. Because of the short time span of most stream gage records (several decades) it is difficult to predict with certainty the frequency of very large floods.

The recurrence interval (T) for annual peak floods on a stream can be estimated as follows:

$$T = (N+1) / (M)$$

where N is the number of years of record and M is the rank order of each year's peak discharge (e.g., the largest flood is rank order 1, the second largest is 2, etc.).

Then, a graph of peak discharge frequency is prepared by plotting the recurrence interval on the X-axis (logarithmic scale) and peak annual discharge on the Y-axis (linear scale).

Following is a table of peak annual discharges (the largest stream discharges in a year) on the Nissequogue River in Smithtown, NY measured from 1970 through 2004.
(data from <http://waterdata.usgs.gov/nwis>, 2008)

date	Q (cfs)	rank order	T (yr)
Apr 2, 1970	82		
Feb 8, 1971	93		
Nov 29, 1971	71		
Oct 7, 1972	117		
Sep 2, 1974	99		
Aug 7, 1975	93		
Aug 10, 1976	130		
Mar 22, 1977	86		
Jan 26, 1978	179		
Jan 22, 1979	952		
Apr 10, 1980	121		
Nov 28, 1980	82		
Jun 5, 1982	165		
Aug 12, 1983	201		
May 31, 1984	160		
Aug 30, 1985	102		
Jul 27, 1986	102		
Mar 31, 1987	92		
Jul 24, 1988	77		
May 17, 1989	153		
Aug 24, 1990	126		
Oct 14, 1990	271		
Jun 6, 1992	128		
Dec 11, 1992	109		
Jan 28, 1994	119		
Jan 7, 1995	58		
Apr 16, 1996	119		
Oct 19, 1996	109		
Jun 13, 1998	150		
Jan 3, 1999	165		
Apr 22, 2000	193		
Mar 30, 2001	123		
Aug 29, 2002	90		
Jun 22, 2003	121		
Apr 13, 2004	137		

- 1) Complete the table above. Rank each peak discharge from largest (rank = 1) to smallest (rank = N). Calculate the recurrence interval (T) for each peak discharge.
- 2) Plot the annual peak discharges (Q) vs. the recurrence interval (T) for each record. Use the supplied graph paper (make sure to download the file [log_gumbel.pdf](#) and print it out). This paper has a special logarithmic scale for the horizontal axis best-suited to plotting peak discharge, which has a Gumbel distribution, as opposed to mean discharge which has a normal distribution. Gumbel log-normal graph paper was developed specifically for applications in hydrology and is the standard used by the U.S. Geological Survey for plotting recurrence intervals.
- 3) Draw a line that best fits most of the data. This line can be used to estimate the long term recurrence interval for peak annual flood discharges of any desired size.
- 4) Do all of the points plot on the line? Discuss possible explanation.
- 5) From the graph, estimate how frequently peak annual discharges as large as or larger than the following sizes will occur on the Nissequogue River: a) 100 cfs, b) 200 cfs, c) 300 cfs
- 6) The mean annual flood (the average peak discharge) can be estimated from your best fit line. Using Gumbel log-normal graph paper, the approximate average will have a recurrence interval of 2.33 years. What is the mean annual flood discharge for the Nissequogue River, based on these data?
- 7) From your straight line fit predict the discharge of the "100 year flood"
- 8) Compare this with the size of the largest discharge recorded in this 35 year period and discuss the problems of estimating the frequency (recurrence interval) of large floods.