Extracted from NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 18, Selected Statistical Methods.

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(d) Discussion

The basic uses of regionalization are to transfer data from gaged watersheds either to ungaged watersheds or to locations within gaged watersheds, and to calibrate water resource models. In using regionalization, however, certain basic limitations must be understood.

The prediction equation generally should be used only within the range of the predictor variables used to develop the equation. The prediction equation represents the "average" condition for the data. If the ungaged watershed varies significantly from the average condition, then the variation must be explained by one or more of the variables in the prediction equation. If the variation is not explained, the equation should not be used.

When the prediction equation is used to calibrate a watershed model, values estimated by the regression equation should deviate from the values computed by the model. The magnitude of this deviation is a function of how much the ungaged watershed differs from the average condition. For example, if most of the watersheds used to develop the prediction equation are flat and long and the ungaged watershed is steep and short, the peak flow computed with the watershed model could differ significantly from that estimated by the prediction equation. The prediction equation should not be used when the watershed characteristics are outside the range of those used to develop the equation.

The coefficients of the prediction equation must be rational. For example, peak flow is inversely proportional to the length of the main watercourse, if all other variables are constant. This means that when a logarithmic transformation is used, the power of the length variable should be negative. If a predictor variable has an irrational relationship in the equation, the correlation coefficients of all the predictor variables should be examined before the equation is used. A high correlation coefficient between two predictor variables means that one of the variables can be used to explain how the criterion variable varies with both predictor variables. The accuracy of the prediction equation is not improved by adding the second predictor variable; the equation merely becomes more complicated.

630.1806 Risk

Flood frequency analysis identifies the population from a sample of data. The population cannot be identified exactly when only a sample is available, and this represents an important element of uncertainty. A second source of uncertainty is that even if the population was known exactly, there is a finite chance that an event of a certain size will be exceeded.

The measurement of such uncertainty is called *risk*. Typical questions include:

- A channel is designed with a capacity of a 0.02 exceedance probability. Is it unreasonable to expect its capacity will be exceeded once or more in the next 10 years?
- What is the risk that an emergency spillway designed to pass a 2 percent chance flow will experience this flow twice or more in the next 10 years?
- Throughout the United States the Natural Resources Conservation Service has built many flood-control structures. What percent will experience a 1 percent chance flood in the next 5 years? The next 10 years?

These problems can be solved by means of the binomial distribution. Basic assumptions in the use of the binomial distribution are given in the general discussion on distributions. These assumptions are generally valid for assessing risk in hydrology. The binomial expression for risk is:

$$R_I = \frac{N!}{I!\left(N-I\right)!} q^I \left(1-q\right)^{\left(N-I\right)} \qquad [18\text{–}29]$$

where:

R_I = estimated risk of obtaining in N time periods exactly I number of events with an exceedance probability q.

Examples 18–7 through 18–10 show the methods used to measure risk.

Example 18–7 Risk of future nonoccurrence

Problem: What is the probability that a 10 percent chance flood (q = 0.10) will not be exceeded in the next 5 years?

Solution: From equation 18–29, for N = 5, q = 0.10, and I = 0:

$$R_0 = \frac{(5)!}{0!(5)!} 0.10^0 (1 - .10)^{(5-0)}$$

The probability of nonoccurrence is 0.59 or 59 percent; the probability of occurrence is $1 - R_0$ or 0.41.

Example 18–8 Risk of multiple occurrence

Problem: What is the probability that a 2 percent chance peak flow (q = 0.02) will be exceeded twice or more in the next 10 years?

Solution: For nonexceedance of the 2 percent chance event:

$$N = 10,\ q = 0.02,\ I = 0$$

$$R_0 = \frac{(10)!}{0!(10)!}(0.02)^0(1 - 0.02)^9$$

$$= 0.817$$

For only one exceedance of the 2 percent chance event:

$$N = 10,\ q = 0.02,\ I = 1$$

$$R_0 = \frac{(10)!}{1!(9)!}(0.02)^1(1 - 0.02)^9$$

$$= 0.167$$

For two or more exceedances of the 2 percent chance event:

$$R_{(2\text{ or more})} = 1 - (R_0 + R_1)$$

$$R_{(2\text{ or more})} = 1 - (0.817 + 0.167)$$

$$= 0.016$$

In other words, there is a 1.6 percent chance of experiencing two or more peaks equal to or greater than the 2 percent chance peak flow within any 10-year period. If flood events are not related, probably no more than 16 locations in a thousand will, on the average, experience two or more floods equal to or greater than the 2 percent chance flood within the next 10 years.

Example 18–9 Risk of a selected exceedance probability

Given: 20-year record on a small creek.

Problem: What is the probability that the greatest flood of record is not a 5 percent chance event (q = 0.05)?

Solution: For nonoccurrence of the 5 percent chance event:

$$N = 20,\ q = 0.05,\ I = 0$$

$$R_0 = \frac{20!}{0!\,20!}(0.05)^0(1-0.05)^{20}$$
$$= 0.358$$

Therefore, there is a 36-percent chance of the 5 percent chance event not occurring and, conversely, a 64 percent chance that one or more will occur.

Example 18–10 Exceedance probability of a selected risk

Problem: What exceedance probability has a 50 percent chance of occurrence in a 20-year period?

Solution: For 50 percent occurrence in 20 years:

$$N = 20,\ q = ?,\ I = 0,\ R_0 = 0.5$$

$$0.5 = \frac{20!}{0!\,20!}(q)^0(1-q)^{(20-0)}$$
$$0.5 = (1-q)^{(20)}$$
$$1 - q = (0.5)^{\frac{1}{20}} = 0.966$$
$$q = 0.034$$

Or, there is a 50 percent chance that a 3 percent chance event will occur within the 20-year period.