EXPECTED ANNUAL NUMBER OF FLOODS

Expected Annual Number of Floods by Flood Depth

Flood Depth (feet)	Default Estimate	User Estimate
-2	1.123E-01	
-1	5.751E-02	
0	6.450E-02	
1	2.948E-02	
2	1.208E-02	
3	3.677E-03	
4	1.221E-03	
5	4.494E-04	
6	1.801E-04	

Default Flood Estimates

The default estimates of the **Expected Annual Number of Floods** of each flood depth from -2 to 18 feet are shown in the **ORANGE (Default)** column. These estimates are calculated from the flood frequency, discharge and elevation data entered previously. "Expected annual number" of floods does not mean that this number of floods occurs every year, but rather "expected" indicates the long term statistical average number of floods per year.

The default estimates of the expected annual number of floods at each depth are shown in scientific notation because these numbers may vary over an extremely wide range, including very small numbers. For an explanation of scientific notation, see the **Technical Appendix** to this chapter, page 7-7.

Except when annual probabilities approach one, the expected annual number of floods and the annual probability for each flood depth are virtually identical.

For a **LEVEL ONE** analysis, these default estimates of the expected annual number of floods at the site under evaluation should be used.

If flood discharge and flood elevation data from a FIS, or equivalent information, are NOT available, then a LEVEL TWO Flood Hazard Risk assessment must be done.

User-Entered Flood Estimates

If desired, user-entered estimates of the annual probabilities of floods of each flood depth can be entered in the **BLUE (Override Default)** column of the Flood Hazard Table. Making such estimates and other possible modifications of the default flood estimates are discussed below in the **LEVEL TWO Flood Analysis** section.

LEVEL TWO Flood Analysis

There are two ways to conduct a **LEVEL TWO** Flood Hazard Risk Analysis:

1. The flood data entry table (above) can be filled in with estimates based on limited data or informed judgement. Such an analysis will be less accurate than analyses using full FIS/FIRM (or equivalent) data, but flood estimates will be approximately correct as long as the input estimates are reasonable for the area under evaluation. Such an analysis is a **LEVEL TWO** analysis because it requires interpolation or extrapolation of limited data and/or other professional judgement about flood risks.

2. The default values of the **Expected Annual Number of Floods** for each flood depth can be overridden with user-entered estimates. This option requires an independent source of flood data, such as a U.S. Army Corps of Engineers study or other data from a professional hydraulics engineer experienced in flood modeling. Such flood data **MUST** be expressed as **Expected Annual Number of Floods** at the appropriate location and elevation under evaluation. To override the default estimates in the **ORANGE** column, user-entered values are entered in the **BLUE** column. Whenever user estimates of the expected annual number of floods are entered, the program uses these values rather than the default values, although the default values are displayed for comparison to the user-entered values.

A LEVEL TWO Analysis of Flood Hazard Risk requires a substantial amount of technical expertise and should not be attempted without properly qualified professional guidance.

Flood Hazard Risk: Technical Appendix

Flood Recurrence Intervals

Floods are a probabilistic natural phenomenon: it is impossible to predict in what years floods will occur or how severe the floods will be. Flood hazards are often expressed in terms of flood frequencies or recurrence intervals, such as a 10-year flood or a 100-year flood.

A "100-year" flood means that there is a 1% chance per year of a flood at the 100-year or higher flood elevation. A 10-year flood means that there is a 10% chance of a flood of the 10-year or higher flood elevation. In general, the annual probability of a flood of X-years is 1/X. Thus, the annual probability of an 83-year flood is 1/83 or 0.012.

Flood recurrence intervals do not mean that floods occur exactly at these intervals; rather they only express the probabilities of floods. Thus, a given location may experience two 100-year floods in a short time period or go several decades without experiencing a 10-year flood.

Flood recurrence intervals (in years) and annual flood probabilities contain exactly the same probabilistic information. The previous paragraphs explained how to convert recurrence intervals in years into annual probabilities. Conversely, annual probabilities can be converted to recurrence intervals. The recurrence interval in years of a flood depth with Y annual probability is 1/Y. For example, the recurrence interval for a flood with an annual probability of 0.01234 is 1/0.01234 or 81 years.

In the benefit-cost program, flood probabilities are expressed in terms of annual probabilities. If desired, these probabilities can be converted to recurrence intervals by the procedure discussed above.

Flood Exceedance Probabilities

The **Expected Annual Number of Floods** for each flood depth correspond closely to Annual Probabilities of floods. Such probabilities are interval probabilities; that is, they express the probabilities for each flood depth. For example, in the Benefit-Cost Program, the annual probability of a 2-foot flood is considered to be the annual probability for all floods between 1.5 and 2.5 feet of depth at that site.

Flood probabilities are often expressed as exceedance probabilities. An exceedance probability means the probability of all floods greater than or equal to some specified flood. Thus, the annual exceedance probability for a 2-foot flood means the annual probability for all floods greater than or equal to 2 feet.

To avoid confusion, the distinction between interval probabilities and exceedance probabilities must be clearly made. The commonly used term, "100-year flood," is actually an exceedance probability. In other words, the 100-year flood level with an annual probability of 0.01 means all floods greater than or equal to this level. The interval probability of a flood at exactly (within plus or minus 0.5 feet) the 100-year flood level will be smaller (sometimes much smaller) than the exceedance probability for a 100-year flood, because the exceedance probability includes **ALL** floods greater than or equal to the 100-year flood.

For completeness, the benefit-cost program tabulates both exceedance probabilities and interval probabilities, although all calculations are done using the interval probabilities. **Graphs of flood probabilities (both exceedance and interval) may be viewed by clicking on the graph buttons at the end of the flood hazard screen in the Benefit-Cost Program.**

Expected Annual Number of Floods

The Riverine Flood modeling uses an approach outlined by the U.S. Army Corps of Engineers for riverine flooding (Flood Proofing, How to Evaluate Your Options, 1993).

The **Expected Annual Number of Floods** at each flood depth are calculated from the flood frequency and flood elevation data entered by the user, along with the **Zero Flood Depth Elevation** of the building under evaluation.

Data from Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM)

Flood Frequency (years)	Discharge (cfs)	Elevation (ft)
10	279,000	5.8
50	351,000	7.4
100	377,000	8
500	444,000	9.5

The flood frequency data (i.e., 10, 50, 100, or 500 years) correspond to exceedance probabilities (see **Flood Recurrence Intervals** section on page 7-7). The computer program does a regression analysis fit between the logarithm of exceedance probability and flood discharge to obtain a smooth curve relating exceedance probability and flood discharge. Then, flood elevations are read (by the program) from the "rating curve," which is the relationship between flood discharge and elevation. The regression analysis is done in this manner because the relationship between stream discharge and probabilities is smooth whereas the relationship between flood elevation and probabilities may be very irregular because of variations in stream valley shape. Flood probabilities for floods below the 10-year flood elevation are determined using the standard A-1 to A-30 flood curves used previously on FIRMs.

This analysis gives the **Annual Exceedance Probability** for all floods, in one-foot increments of depth. From the **Annual Exceedance Probabilities**, calculated as described above, the **Expected Annual Number of Floods** in a given one-foot increment are calculated from the difference in exceedance probabilities of two flood depths. For example, the expected annual number for a 2-foot flood (i.e., all floods between 1.5 and 2.5 feet) at a given site (with a given **Zero Flood Depth Elevation**) is calculated as the exceedance probability for a 1.5-foot flood minus the exceedance probability for a 2.5-foot flood.

Flood Elevation vs. Flood Depth

For a given flood (e.g., a 100-year flood), the elevation of the flood water surface varies with location along the stream as shown by the **Flood Profile** (see pages 7-2 to 7-4). Furthermore, at a given location along the stream the flood depth corresponding to a 100-year flood varies depending on the **Zero Flood Depth Elevation** of the building under evaluation. In the Benefit-Cost Program, the **Expected Annual Number of Floods** are shown for each flood depth from -2 to 18 feet **for the building under evaluation**. For a different building with a different **Zero Flood Depth Elevation**, the **Expected Annual Number of Floods** for each flood depth will be different. Thus, for example, the depth of a 100-year flood will differ for buildings at different **Zero Flood Depth Elevations**.

Review of Scientific Notation

The annual probabilities of floods are expressed in scientific notation because the probabilities may vary from nearly 1 to much less than 1 in a million (0.000001). Scientific notation is a widely-used convenient method of expressing numbers which vary over a very wide range.

In scientific notation, as in the **Calculated Annual Probability of Floods** table, numbers are expressed in two parts: a prefix and a power of 10. For example, 6E+02, where 6 is the prefix and +02 is the power of 10, means 6 times 10^2, or 6 times 100, or 600.

Another way of thinking about scientific notation is that the power of 10 part of the number tells which direction and how much to move the decimal place. Thus, 6E+02 is 6 with the decimal placed moved to places to the positive (right) direction or 600. Thus, 6E+03 is 6000. Scientific notation with negative powers of ten means to move the decimal place to the negative (left) direction. Thus, 6E-02 is 0.06; 6E-03 is 0.006 and so on. E+00, means don't move the decimal place. Thus, 6E+00 is simply 6.

Scientific notation may seem cumbersome with routine numbers, but it is very convenient when numbers are very large or very small or to compare the relative sizes of very large or small numbers. Thus, 6E-11 is a more convenient way of expressing 0.00000000006.