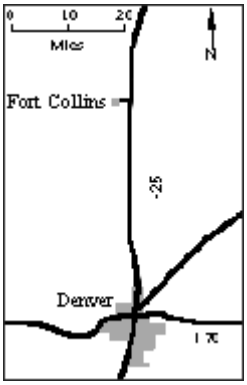
UNCERTAINTY IN ANALYZING HEALTH RISKS

What does "uncertainty" mean?

Uncertainty is defined by Webster's New American Dictionary, 1995 as "something that is not definitely known." We are often faced with uncertainty and, where numbers are involved, we use various methods to evaluate it.

An Everyday Example of Uncertainty: Traveling from one city to another.



If a friend asked about the distance from Fort Collins to Denver, Colorado, you might answer "about 70 miles." A better answer might include an indication of the uncertainty in your answer. The real distance depends on a variety of factors. Which parts of the cities are you traveling from and to? What route do you plan to take? Would you like to know the distance now, 20 years ago, or 20 years in the future? Would you like to know the distance as the crow flies? How accurate is the system you're using to measure the distance? Each of these questions adds to the uncertainty in the answer, and the result might be that the best answer is, "70 miles, with a range of 60-90 miles." Similarly, most of the results of the Rocky Flats Historical Public Exposures Studies are presented as estimates and ranges. This is a good way to present results that are important, but not precisely known.

Many risks to human health cannot be measured, but can be estimated by various means. A risk estimate represents a statistical probability or chance that a health effect will occur under given circumstances. Because we do not know precisely what health effects, if any, will result from exposure to hazardous substances, our estimates of risk will always be somewhat uncertain.

Why does uncertainty exist in analyzing health risks?

Uncertainty exists in analyzing health risks primarily because:

- We do not have complete information.
- Humans react differently.
- Methods of analysis are not perfect.

In some cases, health effects likely to occur in specific circumstances can be calculated fairly accurately because large amounts of actual data exist. In 1996, for example, the National Safety Council reported that 43,300 people died in vehicle accidents. This represents an annual fatality rate of 2.4 deaths per 10,000 drivers, but we would expect this rate to vary from year to year. If accident data for several years were used in the calculation, we could calculate a fatality rate and an uncertainty range, since the actual number of fatalities will vary from year to year.

The result might be presented as a rate and a range. For example, 2.4 deaths per 10,000 drivers with an uncertainty range of 2.2 to 2.6 deaths for 10,000 drivers.

In assessing health risks from past releases and exposures to contaminants, we seldom have complete information about individuals' actual exposures. Estimating risks becomes even more difficult if past events were not fully documented or data on contaminant releases are incomplete. That is the case in the State of Colorado's research on the potential health effects related to past releases of contaminants from Rocky Flats. Consequently, the study team estimated these unknowns using whatever information was available.

Does this mean scientists do not really know the risks related to contaminant exposure?

Scientists cannot accurately predict the health effects that may occur when a community is exposed to contaminants, but scientists can develop an estimate and a range of the chance of an effect. As more complete information becomes available, the estimate improves and the range of uncertainty decreases in size. On the other hand, every time an assumption is made to fill in data gaps, additional uncertainty is introduced into the risk assessment and the range increases in size.

What were some factors that introduced uncertainty into the analysis of past Rocky Flats contaminant releases.

Researchers did not have complete data on past releases from the Rocky Flats Plant, where the contaminants went after their release and to what extent people were exposed. For instance, the amounts of contaminants released in accidents such as the 1957 fire were not measured. As a result, assumptions were made to reconstruct the release and assess the resulting health impacts. For example, the study team made an assumption about the quantity of plutonium that burned, based on estimates of the amount present in the building before the fire and the rate of combustion. Because the resulting release estimate was based on such assumptions, some degree of uncertainty exists.

Computer models also were used to help estimate the amounts of chemicals and radionuclides released from the plant and to simulate their movement in the environment. In some cases, the models required information that was missing or incomplete. Wind and weather data for the actual time period and location of the release might have been unavailable, so the modeler might have substituted data collected for that location in the same season of several other years.

The researchers filled in such data gaps with the best available information. Ultimately, they may have made assumptions and estimates or used representative data from similar circumstances. Those assumptions or data could result in estimates that either underestimated or overestimated the contaminant releases and their potential effects.

How is uncertainty expressed in risk assessments?

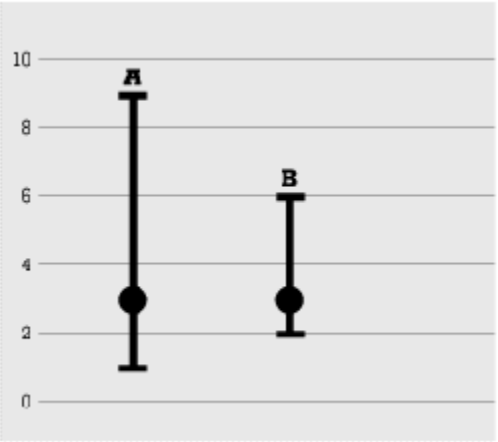
Uncertainty can be presented in a general way, using an estimate and a range. It can also be presented more formally, as a "confidence interval." A "95 percent confidence interval" should include the true value 95 percent of the time.

Can uncertainty be larger for some estimates than for others?

In some cases, the data are fairly complete, and the assumptions and methods used to assess risks have a well-defined scientific basis. A relatively small amount of uncertainty, indicated by a smaller confidence interval, is associated with these assumptions (as shown in the following graph). In other cases, the basis for certain assumptions is limited, so the resulting uncertainty is higher, and the confidence interval is larger.

Confidence Intervals

On the graph, A and B represent estimates in arbitrary units of measurement. The dots show the central tendency, and the vertical bars represent 95 percent confidence intervals.



For A, the best estimate is 3 with 95 percent confidence that the interval of 1.5 to 9 includes the true value. For B, the best estimate is also 3, with 95 percent confidence that the interval of 2 to 6 includes the true value.

In both cases, the best estimate is 3, but the larger interval indicates more uncertainty associated with estimate A. For B, the smaller interval means less uncertainty. Stated another way, we are confident that the true number falls within a smaller range for B than for A.

What is uncertainty analysis?

Uncertainty analysis is the evaluation of the causes and extent of the data gaps in a risk assessment and their effect on the resulting risk estimates. An uncertainty analysis can be a discussion of these data gaps and their impact on the results (qualitative), or it can be a more complex mathematical evaluation of the statistical probabilities associated with a range of possible results (quantitative).

What is its purpose?

The purpose of analyzing uncertainties is to identify the largest and most important factors that affect our confidence in the results of a risk assessment. By identifying the most critical data gaps, research efforts can be focused on better defining those areas that introduce the most uncertainty into the assessment.

Was anything done to reduce uncertainty in the estimates of risk that people face who were exposed to past contaminant releases from Rocky Flats?

Uncertainty in analyzing past Rocky Flats releases and potential health effects could not be eliminated because historical information was incomplete. The first step in reducing uncertainty was searching for and analyzing all possible sources of information that could be useful in the analysis. Second, the researchers looked for sources of supplemental data. For example, uncertainty in the data available from recent environmental sampling could be reduced by taking additional samples for comparison and verification of the previous results, including the use of teams of outside experts to evaluate the initial estimates and recommend procedures for improving the state of knowledge.

Although uncertainty could not be eliminated, the overall goal for the Rocky Flats Historical Public Exposures Studies was to perform the best possible analysis using all available relevant information to improve confidence in the results.